ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. LII. No. 8. New York, August 25, 1904.

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THE WATERWAY OF THE FLORIDA COAST LINE CANAL AND TRANSPORTATION CO.

By George F. Miles.*

An enterprise which up to the present time has attracted very little attention, though of considerable importance to the transportation interests of the eastern coast of Florida, is the construction, now in progress, of the inland waterway of the Florida Coast Line Canal & Transportation Co. This work, when finished, will open to navigation an inside passage for light draft steamers, barges, and yachts, something over 500 miles in length, between Jacksonville and Key West.

In order more readily to understand the situation, it is necessary to call attention to the peculiar formation of the territory bordering the Atlantic coast of Florida, where, inside a comparatively narrow strip of land, are situated several tidal rivers or lagoons, which were disconnected before the canal company commenced operations, but which the canals of the company are now forming into a continuous inside waterway without a single lock for its whole length. Many of these natural waters are already well known to the public, such as the Halifax and Indian Rivers, Lake Worth and Biscayne Bay, all of which are now much used by pleasure craft of various kinds during the winter seasons. It is not, therefore, unreasonable to assume that when vessels of suitable draft can leave the St. Johns River, at Jacksonville, and run down this inside passage, past the historic old city of St. Augustine, and the newer resorts of Ormond, Daytona, New Smyrna, Rockledge, Palm Beach and Miami to Key West, there will be afforded to winter visitors to Florida a new attraction which cannot fail to make the East Coast one of the most popular resorts in America.

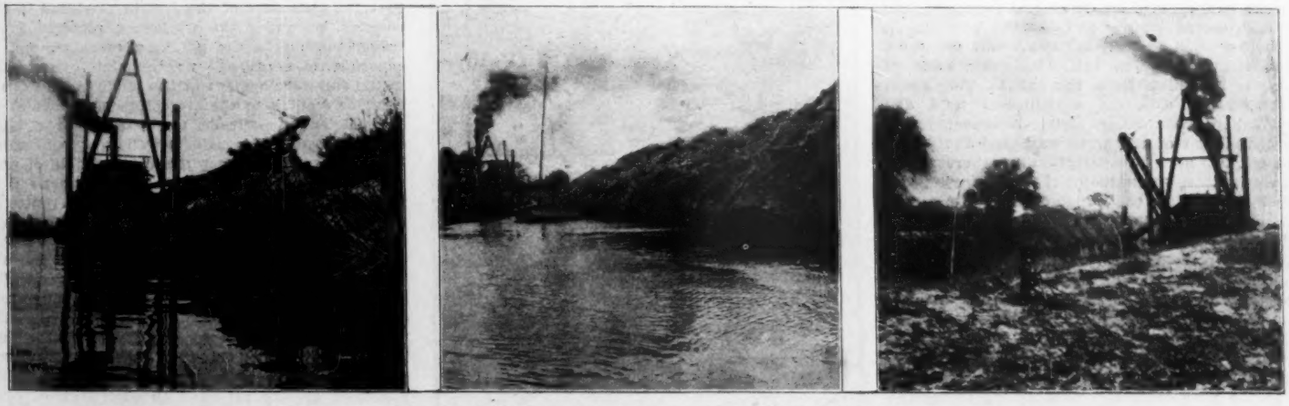
*Managing Director of the Florida Coast Line Canal and Transportation Co.

From an engineering standpoint the work of the canal company is very simple. It consists of cutting canals of various lengths through the divides separating the natural waters, and of deepening shoal places in these waters, in order to obtain a continuous channel of not less than 60 ft. in width and 6 ft. in depth at mean low water.

At the present time the work is being prosecuted on the division between St. Augustine and Biscayne Bay, and the last divide blocking continuous navigation on this division—that between St. Augustine and Ormond—is now being cut through. The length of the canal through this divide or stretch of country, will with approaches, be approximately 24 miles, of which about 15 miles are already cut, and, on the uncompleted section, work is being pushed night and day with a view to opening for traffic the canals between St. Augustine and Miami during the coming year. A considerable amount of dredging was necessary in order to obtain the desired width and depth in the Matanzas River, between this unfinished canal and St. Augustine, and also in the Halifax River, both north and south of Ormond.

Between the Halifax and Indian Rivers a canal through a rock divide, commonly known as the "Haulover Canal," has been cut by the company, and the channel of the Indian River (which is 134 miles in length) between the "Haulover" and Jupiter has been deepened and otherwise improved where necessary. From Jupiter Inlet and Light House, which are situated at the southern end of the Indian River, the canal company has opened up an inside passage to Lake Worth, which involved the construction of a canal six miles in length, and other necessary improvement work. From the southern end of this canal the waterway follows the natural channel of Lake Worth, past the great winter resort of Palm Beach, for a distance of 22 miles; and from the southern end of the lake a series of canals, aggregating approximately 40 miles in length, have been constructed in order to connect Lake Worth and the waterway north of the lake with Biscayne Bay. When the canal now in process of construction between St. Augustine and Ormond is completed, it is the intention of the company to immediately proceed with the work between Jacksonville and St. Augustine, and later on to open up the passage inside the Keys, or islands, between Biscayne Bay and Key West.

During the progress of this work the dredges of the company encountered a great variety of material, which ranged from comparatively hard coral rock (which had to be moved by means of dynamite) to soft mud, the excavation of which at times proved more troublesome and expensive than that of rock. At one point the sliding propensities of this material proved so serious that, after trying every known way of overcoming them, it was found necessary to attach long chutes to the "A" frame of one of the dredges, and by "dumping" the material from the dipper into these chutes it was found that it could be spread over the adjoining marshes in thin layers, thus disposing of it permanently. On the section of the canal where this difficulty occurred, before the waterway was opened the country was completely covered with water, in places to a depth of over 2 ft., though the general level of the ground was between 5 and 6 ft. above tide water. The heavy grasses and other forms of vegetation, however, prevented the water from flowing freely until the canals were cut, after which the land became perfectly dry, and it is now annually producing heavy crops of tomatoes and other vegetables, and several farming villages have sprung up on the banks. It will, therefore, be seen that this work will serve a double purpose, as it will provide not only a



DIPPER DREDGE AT WORK AT NORTH END OF MATANZAS-HALIFAX CANAL.

cheap and attractive transportation route, but where it passes through portions of the country which require drainage it will furnish a main drain capable of carrying the water from a very considerable territory on both sides of the canal.

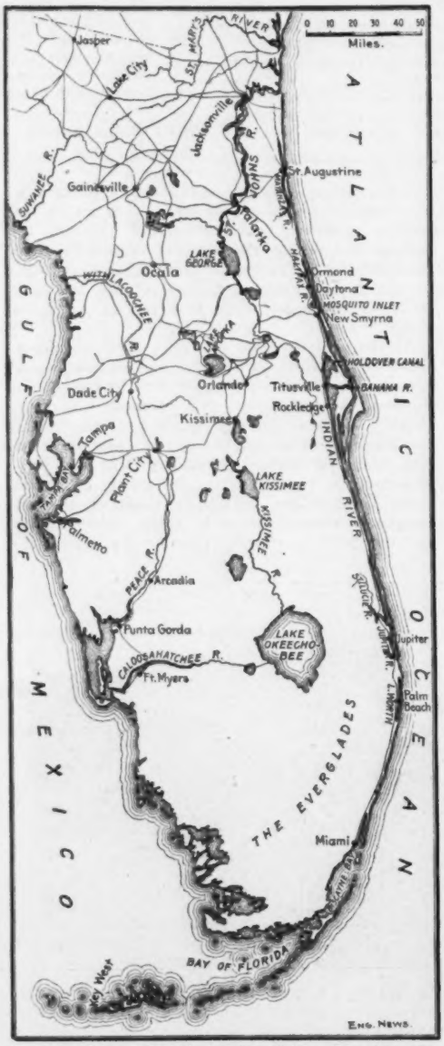
At many points on the sections of the work already done the cutting has been moderately heavy, notably through the high country between Jupiter and Lake Worth, where at one point the cut was 22 ft. in depth from the surface of the ground to the bottom of the canal. On this section it was found necessary to build a temporary railroad for construction purposes, and to remove a large amount of the material on cars until it could be handled by dipper and suction dredges. Such machines were, however, at once placed in operation in this deep cutting when it was found that they could be used economically.

Since commencing operations, the canal company has used almost every form of dredging machine. Several millions of cubic yards have been excavated, and the question of finding effective machinery was, therefore, a serious one. The first dredges used were of the endless chain, or elevator type, but they were soon abandoned owing to the constant wearing out of the links connecting the buckets. Later, "clam-shell," "dipper," and "suction" machines were tested, but after careful observation it was found that dipper and suction dredges proved most effective and economical. The great variety of material which had to be dealt with, and the difficulty of reaching machine shops, made a simple form of dredge essential, and, for this reason, for actual digging through solid ground, dipper machines of the Osgood type were decided on, and for dredging shoals of recent formation, and maintenance work generally, centrifugal sand pumps have proved most effective. For the foregoing reasons the canal company's plant is now altogether composed of dipper and suction dredges, the machines being equipped with unusually long booms, and being otherwise fitted out to deal with any class of material which they may meet with.

In order to encourage and aid the construction of this waterway, the state of Florida granted to the canal company 3,840 acres of land per mile for a distance of 326 miles between St. Augustine and Biscayne Bay, all of these lands lying within a belt, the outer limit of which is ten miles from the canal. This grant includes some excellent agricultural land, and some fairly good timber, and it is expected that the completion of the waterway, and the establishment of a new transportation line thereon, will largely increase the value of the company's property by adding to the population and by giving new impetus to all industries along the route, and throughout the adjoining country.

Up to a comparatively recent date the steamboat business in Florida proved one of the most important factors in the development of all sections of the state bordering navigable waters, and at the present time both on the St. Johns and several of the western rivers profitable lines are being operated in competition with railroads. Up to the year 1886 the country adjoining the Halifax and Indian Rivers was almost a desert, as it had practically no transportation facilities; and south of Jupiter, the state, on the eastern side, was known only to a few enterprising settlers, who seemed to realize that the day was not far distant when that section of the country would be placed in touch with the rest of the world. These pioneers bought land, and while trying, under great difficulties, to cultivate it with profit, they waited for developments, which eventually came and promptly made many of them comparatively rich men. About 1886 a narrow gage railroad was built from the St. Johns River near Palatka to the Halifax River at Daytona, the road first being used for logging purposes, and later on for general traffic, when a small steamer was placed in operation to connect Daytona with the older settlement of New Smyrna, which is situated on the Halifax near Mosquito Inlet. This was the first effort made to open up a regular transportation service in that part of the state, and the development of the Halifax River country has since proved that the work was not labor lost.

About this time, too, or perhaps a few months earlier, a branch of the Jacksonville, Tampa & Key West Ry. was built to the Indian River, terminating at Titusville, and one or two steamers commenced to open up the Indian River route in connection with this road. A year or two later the Indian River Steamboat Co. was organized, and several good steamers were built and placed on the route between Titusville and Jupiter. The advent of this combined steamboat and railroad service to and from the outside world inspired the few farmers and fruit growers then on the river to increase the acreage of their plantations, and new people were induced to settle in the country, with the result that in a short time additional steamboats were needed, until in 1890-91 the company had no less than eight vessels in



General Map of the Florida Coast Line Canal Route; Between Jacksonville and Miami.

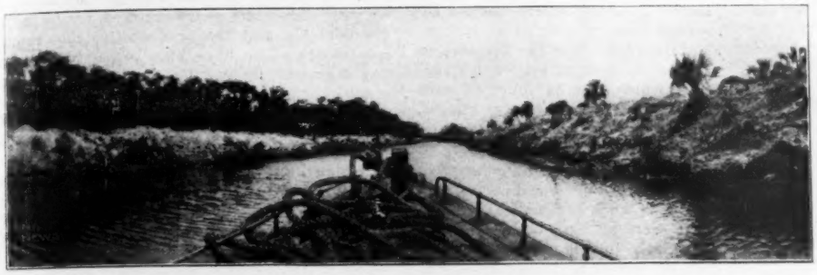
the service. In the meantime an extension of the route had been effected by the construction of a narrow gage railway, eight miles in length, from Jupiter to Lake Worth, and a small steamer had been placed in operation on the lake to connect the southern terminus of this short railway with Palm Beach, which then consisted of a few scattered houses built in some young cocoanut plantations. It is difficult to realize that a few years ago the place which is now the site of one of the most famous winter resorts in the world could only be reached by a tiresome railroad journey to the head of the Indian River, then a sailboat voyage of about 130 miles to Jupiter, then a drive of eight miles through the woods in a mule cart, after which another sailboat trip of ten miles brought the traveler to the point on Lake Worth where the Royal Ponciana Hotel now stands. A year or two later the construction of the short railway above mentioned somewhat improved the transportation facilities, but even then nothing but the great beauty and charm of Palm Beach could have succeeded in drawing winter visitors so far into what were at that time, the wilds of South Florida.

In 1893 Mr. Flagler commenced his great work of development which has since, through his system of railroads and hotels, opened up the east coast of Florida to thousands of northern visitors as well as to the fruit and vegetable growers who are now making that section of the country the winter garden of the United States. When Mr. Flagler first considered the extension of his railroad to the south, he was confronted with the fact that the canal company controlled, through its charter, all of the state lands lying within ten miles of the coast. After some negotiation, however, this difficulty was removed through an arrangement by which the canal company agreed to subsidize the railroad to the extent of 1,500 acres of land per mile for each mile of road constructed between Rockledge (on the Indian River) and Miami (on Biscayne Bay). At first sight it seemed rather difficult to understand why the canal company should encourage the construction of what appeared to be a competitive transportation line, by granting it, as a subsidy, over a quarter of a million acres of land, but nevertheless the directors of the company considered it good policy to foster every enterprise which promised to more rapidly open up the country, and so increase the value of its remaining lands which with those held in reserve for the company by the state amounted to, approximately, 700,000 acres. It was also realized that with good railroad facilities, added to the attractions which the completion of this waterway would provide, the east coast of Florida could not fail to become the great winter resort of the United States, and the wonderful development of the last few years, including the construction of the great hotels of the Florida East Coast Hotel Co., has fully justified the policy of the directors of the canal company in making a liberal land donation to the railway. In addition to this it was quite evident that the character of the freight produced in the country bordering the waterway required rapid transportation to the northern markets, and in consequence a railroad was absolutely necessary to the full development of the lands in that territory; as well as to the attraction of a population of sufficient magnitude to warrant, at a later date, the establishment of a well equipped steamboat line on this new waterway, capable of providing a first class service on what cannot fail to prove one of the most attractive tourist routes in America. Also, it was, and is, expected that general merchandise, lumber, and other heavy freights to which quick transportation is not essential, can be more cheaply and conveniently carried by steamers than by rail. An important section of the country, too, which will be specially benefited by water transportation is that which lies to the eastward, between these inland waters and the Atlantic Ocean, the development of which has been greatly retarded through lack of convenient transportation. When, however, the steamers of the canal company are placed in operation, they can serve both sides of the waterway with equal facility, and the fertile lands on the east side can be developed as readily as those through which the railroad now runs, on the west.

It is a noticeable fact that the majority of the plantations and residences along the east coast of Florida are located on the shores of the inland waters which the canal company is connecting. To some extent this may be accounted for by the fact that the first transportation system established in this territory was a steamboat line, and water frontage for wharves proved a great convenience. Later on, however, the discontinuance of the steamboat service, owing to the loss of its railroad connection, changed the conditions considerably, but nevertheless "water front" lands seem to have lost nothing of their popularity, and the borders of the waterway show more development and activity than any other section of the east coast country.

When the canal route is open to Jacksonville,

the company will have no lack of connections for northern and western business, as at the present time there are three large railroad systems entering the city, viz.: the Southern, the Seaboard Air Line, and the Atlantic Coast Line, while the Clyde Steamship Co. has from three to four large coasting steamers entering and leaving the port each week. The channel leading from the ocean to Jacksonville, too, is being substantially improved by the general government, and within a short time vessels drawing over 20 ft. will be able to reach the wharves in front of the city at low water. At Miami, also, the present southern terminus of this waterway, extensive harbor works are in progress, so that in the near future the canal company will have first class harbor facilities at both ends of its line.



NORTHERN END OF MATANZAS-HALIFAX CANAL; WITH TYPICAL SHORE VIEW.

As a tourist route the advantages of this new enterprise will be more fully appreciated when it is realized that all of the east coast towns and hotels are situated on the banks of either the natural or artificial channels, and also when it is understood that while passengers on the company's steamers will have the full benefit of the Atlantic breezes from the ocean lying to the eastward, they will be subject to no unpleasant motion, as the passage is land-locked for the whole distance from Jacksonville to Biscayne Bay.

In conclusion, it may be mentioned that in addition to the opening of the main route between St. John's River and Key West, the works of the canal company will supply an outlet to three important tributary water courses, viz.: the Banana, St. Lucie and Jupiter rivers. All of these streams are bordered by fertile lands, which will soon be brought under cultivation, thus extending the influence of this canal system to the borders of the Everglades on the west, and to Cape Canaveral on the east.

SEASIDE SEWAGE DISPOSAL.*

By Arthur J. Martin,† Assoc. M. Inst. C. E.

The problem of sewage disposal in a seaside town differs in many respects from that with which an inland local authority is called upon to deal.

The first and most obvious point of difference is that, whereas an inland town is invariably called upon to purify its sewage, the necessity for doing so seldom arises where the discharge takes place into the sea. The town possessing a well-chosen sea outfall is therefore relieved from the expense of laying down and operating purification works, and from the anxiety bred of present difficulties in satisfying the requirements of the law, and the prospect of the latter becoming still more stringent in the future. It may be said of an efficient sea outfall that it gives a nearer approach to finality than any other mode of disposal as yet in vogue.

Before discussing modes of treatment, it may be well to consider what becomes of sewage after it is discharged. If this takes place in a strong current in deep water, the outgoing stream speedily loses its identity and mixes with the salt water, particularly when the sea is rough, and in such a case the solids will probably be dispersed, ultimately serving as food for fish or plants. In still water the diffusion takes place much more slowly; and the sewage preserves its identity for some time, as, being appreciably lighter than salt water, it rises at once to the surface and rests there as a distinct layer.

Professor Letts, of Queen's College, Belfast, in his evidence given before the Royal Commission on Sewage Disposal, supplied some interesting information as to the behavior of sewage in sea water.

(1) Under no circumstances is a nuisance likely to arise from sea water contaminated with sewage up to 1%.

(2) In such a mixture a rapid action occurs between the dissolved oxygen of the sea water and the constituents of the sewage, whereby part of the carbon of the latter is evolved as carbonic anhydride, and, probably speaking, this latter is equivalent in amount to that of the dissolved oxygen disappearing.

(3) In mixtures of sea water and 1% sewage the changes occurring in the nitrogenous constituents of the sewage as measured by free and albuminoid ammonia and the nitrates are very slow. In no case has the whole of the free ammonia nitrified, even after the lapse of an interval of 21 months; on the contrary, complete denitrification had then occurred.

The fluctuations in the amounts of free ammonia, albuminoid ammonia and nitrates are very possibly due to the growth of lower forms of plant and animal life, in addition to bacteria.

The fate of the sewage solids was referred to by another witness, Mr. G. R. Strachan, who gave some instructive evidence. An outfall which had not given "any signs of surface pollution, nor any signs whatever of pollution by putrescence," might yet, he pointed out, "be causing a deposit on the bed of the sea." He mentioned a case in which, in the course of excavation for a pier, old sewage debris was found in considerable quantity at a distance of 500 yds. from the outfall, where it had lain quite unsuspected, giving rise to no nuisance.

In the large majority of cases all that is required is to intercept the solid matter in the sewage. This may be effected, so far as the larger solids are concerned, by simple screening, and where this is deemed insufficient, the fine suspended matter may also be removed to a limited extent by sedimentation, or more thoroughly by chemical precipitation. The application of any of these methods is often hampered by the difficulty of obtaining a suitable site for the necessary plant. This must generally be placed in the lowest part of the district, so that the whole of the sewage may be conveniently gravitated thereto, and the lowest part of a seaside town is in most cases the sea front. Mr. Chatterton, in his evidence before the Royal Commission, refers to the extreme difficulty which is sometimes experienced in obtaining even the small plot of land required for a screening chamber, and if the treatment is to be more thorough, involving larger works, the difficulty will be still greater. Even where the necessary ground can be obtained, there remains the grave objection to placing on the sea front any works which are visible which demand constant attention or from which screenings or sludge have to be periodically removed. These considerations will in the majority of cases effectually bar the adoption of the methods in question. An authority is thus thrown back on the necessity for destroying the solids (or as much thereof as possible) by septic action, and where treatment has been adopted in recent years this is the mode generally resorted to. Instances of this occur at Morecambe, Cromer, Walton-on-the-Naze, Sheringham and Gosport, in this country, and Greystones, near Dublin. At Vancouver, British Columbia, three septic tank installations have already been laid down, and others are under consideration.

A mode of treatment having been selected, it remains to consider the question of discharge. If screens or septic tanks are used, the treatment will involve no loss of fall; whereas with precipitation or sedimentation it will be necessary to have an outlet from the bottom of the tanks. The level of the outlet will be a factor in determining the mode of discharge. If it is above high-water level of spring tides the effluent may be discharged at all times; otherwise storage room must be provided for the effluent. Where sewage is to be discharged in a crude state, storage will almost certainly be required for the purpose of limiting the discharge to such times as the set of the currents is away from the town and beach. With an effluent containing no solids to float on the surface or drift back on to the beach, the necessity for limiting the discharge will be lessened, if not done away with, and where the levels are such as to admit of discharging the effluent at all times, it will generally be better to do so than to store it for several hours and discharge the accumulation suddenly. It should be remembered that a sewage effluent, however purified, is lighter than sea water, and will, if it gets a chance, rise to the surface, where by reason of the difference in density, and possibly of a slight greasiness in the effluent, it may, if discharged in large volume, show as a dark patch. The presence of the outfall will thus be indicated, thereby to a great extent defeating the object of the treatment. This discharge is also liable to be betrayed where the sewage is discolored by large quantities of road mud, particularly if the outfall is shallow, or the sewage is stored and discharged in large volume.

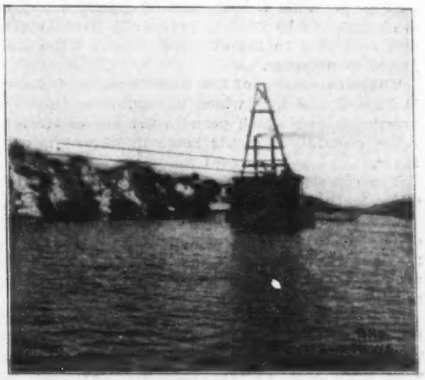
While the treatment of sewage by the removal of its suspended solids does not in ordinary cases do away with the necessity for carrying the outfall pipe below low-water mark, it will generally admit of keeping this pipe much shorter than would otherwise be necessary, and often permit it to be placed in a position where the discharge of crude sewage could not have been tolerated. The expense thus saved will often go far towards paying for the tanks, particularly if the foreshore is flat or so unstable as to necessitate costly means of anchoring and protecting the pipe.

Where the sewers, or some of them, are below high-water mark, and storage room must therefore be provided, it may take the form either of a tank or a tank sewer. The latter is much more expensive than the former, and the storage of crude sewage is objectionable, being less readily cleared than a tank. Whichever is used, the greatest care should be taken with its cleansing and ventilation, as there is no more fruitful cause of well-grounded complaint in seaside towns than the foul air which is ejected from tide-locked sewers as the sewage rises therein.

The outlet from a storage tank must always be controlled by valves to prevent the ingress of the tide, and if crude sewage is stored, these will have to be opened and closed at such times as the currents set in the required direction. This work may be performed by hand, but inasmuch as it will have to be done at all hours of the day and night, and the times will vary from day to day, it is better to put in automatic apparatus for the purpose. The Board of Trade, whose sanction has generally to be obtained to the laying of any pipe across the foreshore, have, in several cases, stipulated that the discharge valve be fitted with an indicator, so that it may be seen from a distance whether the valve is closed or open.

An inland town groaning under the cost of an expensive sewage farm or filters, and moved by envy at the immunity of its seaside sister from this burden, may be tempted to cavil at the discharge of an unpurified effluent as falling short of the high standard to which a progressive municipality should aspire. Those who have at heart the good name of our fashionable watering-places need have no misgivings on this score, for the discharge of an effluent free from solid matter, and well on the road to purification, into a large and fully oxygenated body of water is as efficient a means for completing its purification as to turn it over land or through a filter, and is in full accordance with the latest teachings of sanitary science.

In dealing with a theme so well worn as this, it is impossible to avoid traversing much familiar ground. In the absence of new information on the subject the author has contented himself with an attempt to put some of the old facts in new lights, and to draw attention to one or two phases of the subject which do not always receive the consideration which they deserve.



Jupiter-Lake Worth Canal; About 10 Miles North of Palm Beach. Showing Conveyors for Dredged Material.

The conclusions which he has arrived at may be briefly summed up as follows:

(1) That under certain exceptionally favorable circumstances the discharge of untreated sewage may yield perfectly satisfactory results.

(2) That under ordinary conditions the separation of the solids is desirable.

(3) That this may be partially accomplished by screening, and more effectually by sedimentation, precipitation or septic action.

(4) That under ordinary conditions septic treatment will be most satisfactory.

(5) That the effluent should, if possible, be discharged continuously.

(6) That if storage is inevitable, it should take place

*Abstract of a paper read before the Royal Institute of Public Health, at Folkestone, England, July, 1904.

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in a tank rather than a sewer, and that the opening and closing of the valves should be effected automatically.

(7) That the utmost care should be taken in selecting the point of discharge.

(8) That of the foregoing conclusions none except the last applies in all cases, and that in dealing with sewage, either by the sea or inland, the only safe rule is to treat every case on its own merits.

A NEW WATER TUBE BOILER.

We illustrate herewith a water tube boiler, which was designed by the former chief engineer and general superintendent of the Colorado Fuel & Iron Co.'s Pueblo plant, and which is now being manufactured by the Rust Boiler Co., of Pittsburg, Pa.

Fig. 1. Drum of Water-Tube Boiler with Tubes Bent to Enter Drum at Right Angle.

Fig. 2. Drum of Water-Tube Boiler with One Side Flattened for Tube Connection.

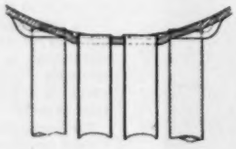

Fig. 3. Part Section of Pressed Tube-Sheet of Drum of Rust Water-Tube Boiler.

The most novel feature of this boiler is the pressed tube sheet used in the construction of the drums. This tube sheet is pressed in a heavy hydraulic press fitted with suitable dies, and is so formed that for each tube there is a pressed-up portion of the shell, the surface of which is at right angles to the direction of the tube. Between each pressed-up portion and the adjacent ones there remain undisturbed cylindrical portions or belts of the original surface of the drum. These undisturbed cylindrical portions or belts give the drum ample strength and stiffness against deformation under pressure.

In former designs of water tube boilers consisting of banks of tubes connecting cylindrical drums without flat stayed surfaces, it has been necessary to use bent tubes in order that they should enter the shells of the drums normal to the face, as shown in Fig. 1. These bent tubes are well known to be much more difficult to inspect, clean or repair than straight ones.

Other designs of boilers employ flat tube sheets in order to avoid the use of bent tubes, as shown in Fig. 2. This flat surface is objectionable, as stays have to be used to prevent it from bulging and returning to the cylindrical form when subjected to pressure.

The construction of the Rust tube sheet, shown in Figs. 3 and 4, in which the cylindrical form is preserved, and which permits the use of straight tubes certainly presents some important advantages.

The cross section of the boiler, Fig. 5, makes other features of the construction clear.

The external type of furnace is particularly conducive to complete combustion. This furnace may readily be extended to permit sufficient grate area to be used to suit any kind of fuel and the application of any kind of grate bar or stoker.

The baffle wall consists of tiles placed between the two rows of tubes forming the central bank. These tubes securely hold the tile and tend to keep them cool, so that they are less liable to burn out.

The tubes of the main banks are cleaned from the interior of the drums, and those of the central bank through hand holes in the headers. In this respect the boiler has the advantage over the horizontal type of water-tube boiler, in which two hand-hole covers have to be removed and replaced for every tube cleaned. The design insures a good circulation, any tube may be removed and replaced without disturbing any other tube or any part of the setting and the long flue-ways allow ample time of contact between the hot gases and heating surfaces.

The first boilers of this type were built for the Minnequa plant of the Colorado Fuel & Iron Co., at Pueblo, Col., and others have since been installed in Pittsburg plants.

FACING AND FINISHING EXPOSED CONCRETE SURFACES.*

The difficulty of securing an even grained surface of uniform color on concrete work is one of the most annoying which builders of such work have to overcome. Concrete work is subject to various sorts of surface imperfection, but the two most common imperfections are roughness or irregular surface texture, and variability of color or discoloration. Either of these imperfections is capable of disfiguring an otherwise sightly structure, and the task of avoiding them is one which warrants serious attention from those undertaking work in reinforced concrete. Unfortunately, practice has not settled upon a solution of the problem, hence its consideration here is rather a record of experience than a set of instructions, which can be followed with the certainty of successful results.

CAUSES OF ROUGHNESS AND DISCOLORATION.—There are several conditions which may result in a concrete surface of uneven texture and with mechanical roughness, such as projections, bulges, ridges, pits, bubble holes and scales. One of these is imperfections in the molds. The use of rough lagging of uneven thickness and with open cracks and allowing the forms to become distorted and warped are certain to leave their impress upon the plastic concrete in the form of ridges, tongues and bulges. Failure to pack the concrete filling tightly and evenly against the mold will result in rough places. Lack of homogeneity in the concrete is another prolific cause of variation in the surface texture of concrete work. This lack of homogeneity may result from failure to mix the concrete materials thoroughly and evenly in the first place, or to the segregation of the coarse and fine parts of the mixture during its deposition and ramming into place. In both cases the result is a material of alternate coarse and fine texture. Dirt or cement adhering to the molds will leave pits in the concrete surface, and the pulling away of the concrete in spots where it adheres to the molds when they are removed will cause similar roughness.

Variations in the color of concrete surfaces probably result from a variety of causes. Some of them are obvious and others are difficult to determine with any exactness. Roughness or uneven surface texture is a common cause of variation in color, since the alternate rough and smooth parts weather differently and collect and hold dirt and soot in different degrees. Another cause of variation in color is the use of different cements in adjacent parts of the surface work. No two cements are of exactly the same shade of color, and the concrete made of them partakes of this variation. In a similar manner sand of different shades of color or of different degrees of cleanliness will cause a cloudy and streaky appearance in concrete. Dirt adhering to the molds will frequently stain the adjacent concrete surface.

Even when the smoothness of the surface is satisfactory, however, and when there is no criticism possible as to the kind and quality of the aggregates, their deposition and the cleanliness with which the work is done, concrete surfaces frequently vary in color and have a cloudy light and dark appearance. In many cases there seems to be good reason for attributing this to the slacking out of lime compounds and their deposition in the form of an efflorescence on the concrete surface. The extent of this efflorescence varies; at times the deposit is so thin as merely to give a lighter shade to the places where it appears, but it will often form an incrustation of considerable body and thickness, which may be readily scraped off as a white or yellowish-white powder. The nature of this discoloration and the preventative and remedial treatments which have been practiced in its cure are discussed more fully in a succeeding paragraph.

CONSTRUCTION OF FORMS.—Very slight imperfections in the face of the forms against which the concrete is molded are sufficient to leave an unsightly impression on the plastic mixture when it hardens. Even the grain of smoothly dressed timber will show on the surface of concrete which has been deposited with a mortar facing. It is very difficult to construct forms so that they will not leave slight impressions of this character and it is generally better not to attempt the task in any but exceptional instances. In these a straight grained, smoothly dressed timber, with its pores filled with soap or paraffine well rubbed in, or a rougher timber covered with sheet metal, can be used. Generally speaking all has been done that is practicable so far as the forms are concerned when the face lagging is kept true to surface and has close fitting joints. Grain marks and similar minor impressions of the forms can usually be eliminated by rubbing the surface or floating it with grout, at less cost than by attempting to perfect the molds beyond a reasonable measure. In fact, many engineers experienced in concrete work prefer not to attempt to secure particularly perfect finish in the forms, but to dress the entire surface by some form of tooling or rubbing process after the forms have been removed. The most apparent imperfection in concrete surfaces is usually the joint marks of the lagging boards. These may be due either to slight differences in the thickness of adjoining boards or to open joints. The remedy for the first cause is obvious, but it is not so easy to secure smooth, tight joints and keep them smooth and tight when the boards swell from the mixture absorbed from the wet concrete. One of the most successful forms of joint is that shown by the sketch Fig. 1. In this construction the wedge edge presses into the edge of the adjoining board without distorting or bulging the lagging. Pointing the joints with hard soap or putty, packing them with oakum and covering them with pasted strips of cloth are other means which have been practiced for preventing joint marks on the concrete. A method of eliminating grain marks, which was used with success in constructing the piers of the Fraser River Bridge in British Columbia, consisted in covering the tightly lined matched lagging with gloss oil and then blowing sand into the oil with hand bellows.

MORTAR OR GROUT FACING.—One of the

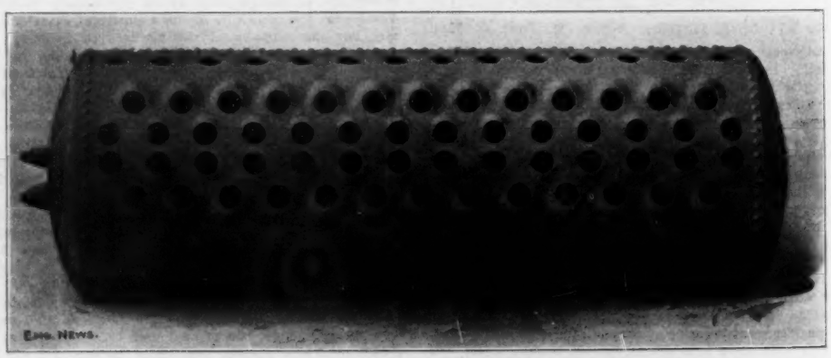

FIG. 4. A 44-IN. DRUM FOR A RUST WATER-TUBE BOILER.

*Extracts from forthcoming book on "Reinforced Concrete," by A. W. Buel and Charles S. Hill.

most frequently employed means for securing a smooth surface finish on concrete is to use a mortar or grout facing. This facing differs from plastering in being laid on as the concrete is deposited, thus forming a single piece with it. The thickness of mortar facing employed in practice varies from ½ in. to 3 ins., but the usual practice is to make it 1 in. to 1½ ins. thick. A facing as thick as 3 ins. is a rather unnecessary waste of mortar, while one which is much less than 1 in. thick is likely to be pierced by the stones in the concrete unless great care is taken in running the concrete behind the mortar facing. A mortar or grout facing shows the impress of small roughness on the mold more readily than does concrete and particular care is necessary to secure a smooth surface on the mold when a mortar facing is adopted. The composition of the facing mortar is usually specified as 1 part of Portland cement to 2 or 3 parts of sand. These ingredients are mixed rather wet, since the paste must completely fill the facing mold, but care must be had not to have so thin a paste that the stones from the concrete behind will be pushed through it during the subsequent filling and ramming.

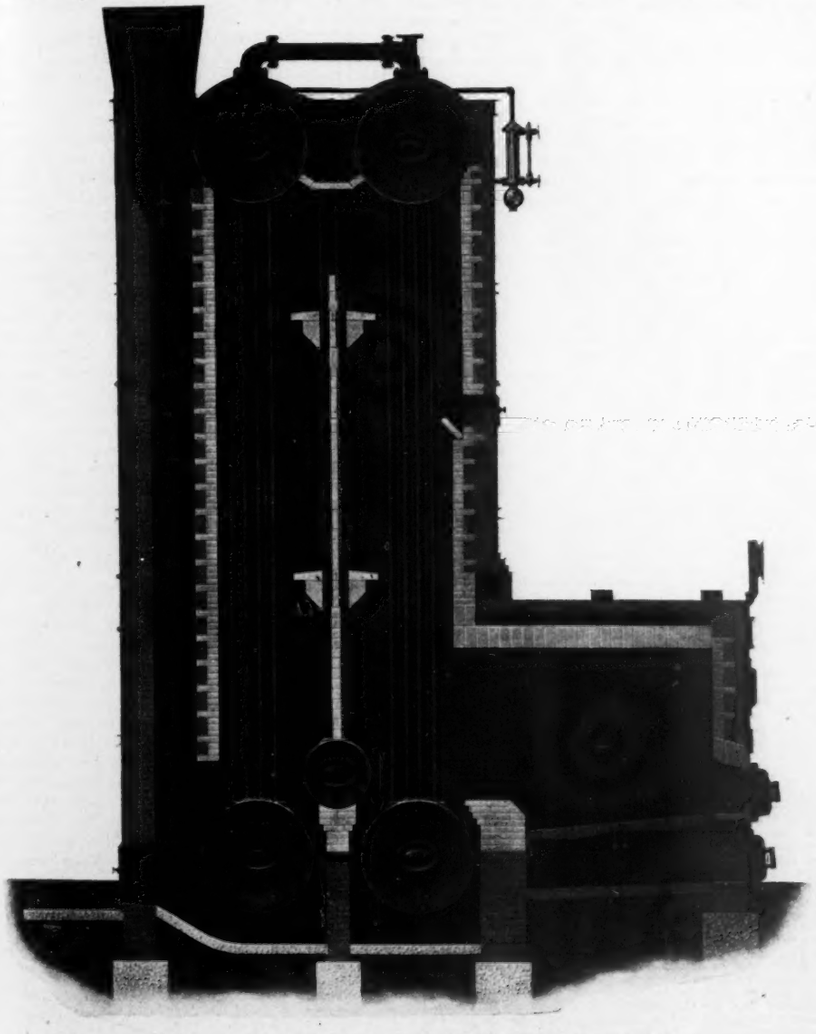

FIG. 5. CROSS-SECTION OF RUST WATER-TUBE BOILER.

The following method of placing the mortar facing is practiced by the Illinois Central R. R. and has gained wide adoption during the last few years. A short iron plate 6 or 8 ins. wide and about 6 ft. long has riveted across it on one side 1½ in. angles spaced about 2 ft. apart. One edge of this plate is provided with handles. This device is employed as a mold for the facing and is operated in the following manner: The plate is set up against the face of the form with its angle ribs close against the timber and its handles upward. In this position of the plate there is between it and the form an open slot 1½ ins. wide. This slot is filled with mortar which is tamped thoroughly and immediately afterwards, the concrete backing is deposited behind the plate. When this has been done the plate is withdrawn by the handles and the backing and facing are rammed together to a close bond. The mortar facing is mixed in small batches as it is needed and no delay is permitted in placing the concrete backing, the essential principle and purpose of the method being to secure as nearly as is possible the simultaneous construction of the backing of concrete and its facing of mortar.

Fig. 2 shows an excellent form of surface mold of the type just described. By varying the size of the angle ribs any desired thickness of facing can be constructed and the flare of the top edges facilitates the placing of the mortar, which is usually done with shovels. In lieu of a steel plate, use is sometimes made of a board provided with furring strips on one side. This is a more unwieldy device than the one illustrated, and it is objectionable because of the large crevice left upon withdrawal, into which the mortar facing is likely to slough and which is less easily closed and bonded by the final ramming. In constructing mortar facing with either iron or board molds, perfect success is secured only at the expense of great care. The mortar must be mixed in small batches and only as needed, and it must be thoroughly rammed and churned into the facing mold. The concrete backing must be deposited behind the mold without delay and firmly rammed against it, and finally the ramming together of the facing and backing must be thorough.

The following method of applying grout facing was employed with success in constructing the Atlantic Ave. subway for the Long Island R. R. in Brooklyn, N. Y. The concrete was deposited in 6-in. or 8-in. layers, and after ramming the concrete at the face, was pushed back from the form about 1 in. with an ordinary gardener's spade, and a thick grout of 1 part cement and 2 parts sand was poured into the space. The forms used were tongued and grooved yellow pine, painted with paraffine paint. In this work a good surface was invariably secured when the men did their work faithfully, but any carelessness on their part evidenced itself in a rough spot when the forms were removed. As an indication of the susceptibility of mortar facing in taking impressions from the forms, it may be noted that even with the dressed and paraffined, lagging the grain of the wood was shown perfectly on the mortar facing.

FINISHING MORTAR FACING.—When mortar or grout facing is employed, as described in the preceding paragraphs, the slightest imperfection in the mold, even the grain of smoothly dressed wood, is clearly impressed on the plastic material. There will also be occasional rough spots, pittings or bubble holes, even with the most careful construction. To get rid of these, some method of surface finishing must be resorted to. A number of methods have been practiced. In recent concrete culvert work on the New York Central & Hudson River R. R., an excellent surface finish was obtained by the following procedure: The forms of 2-in. dressed and matched pine, after being put in place, were painted with a coat of thin soft soap, then as the layers of concrete were brought up the face was drawn back with a square-pointed shovel, the edges of which had been hammered flat. Mortar in the proportion of one part cement to two parts sand, mixed rather wet, was then poured in along the form and the layer rammed against it. Hard soap was used to fill openings left by joints of the lagging. When the forms were removed and while the concrete was yet "green," the surface was carefully rubbed with a circular motion, with pieces of white fire brick or briquettes of one cement to one sand, made in molds about the size of a building brick, handles being pressed in while soft. The surface was then dampened and painted with a coat of grout of one cement to one sifted sand, and this was closely followed by a final rubbing, with a circular movement, using a wooden float. All edges were rounded with a Crafts edger, or with wood fillet, and the coping joints were struck with a Crafts jointer.

In the specifications for concrete presented by the special committee of the Engineering and Maintenance of Way Association, the following requirement for finishing was adopted:

> After the forms are removed, any small cavities or openings in the concrete shall be neatly filled with mortar if necessary. Any ridges due to cracks or joints in the lumber shall be rubbed down; the entire face shall then be washed with a thin grout of the consistency of whitewash, mixed in the proportion of 1 part of cement to 2 parts of sand. The wash should be applied with a brush.

In the extensive concrete construction of the Aurora, Elgin & Chicago R. R., the exposed surfaces were all finished according to the following specifications:

> All walls when finished must present a smooth uniform surface of cement mortar, and all disfigurements must be effaced, and if there are any open, porous places, they must be neatly filled with mortar of one cement and two sand, well rubbed in, which finishing must be done immediately upon the removal of the forms.

Mr. Edwin Thacher, in his general specifications for concrete steel, requires the following surface finish:

> For plain flat surfaces, the concrete may be rammed directly against the molds, and after the molds have been removed all exposed surfaces shall be floated to a smooth finish with semi-liquid mortar composed of one part cement and two parts of fine sharp sand, care being taken that no body of mortar is left on the face, sufficient only being used to fill the pores and give a smooth finish.

A very effective finish is obtained by etching the mortar facing with acid. The method consists in using a facing mortar composed of Portland cement and finely crushed stone, the kind of stone depending upon the appearance desired. Thus any shade of red or gray granite, sandstone, etc., can be obtained, and special effects can be obtained by the use of sand, pigments, etc., in the mixture. This mortar is composed of about 1 part

Portland cement to 2 or 3 parts of the finely crushed stone. The exposed surfaces are then treated by chemical or mechanical means to remove the cement matrix at the face, leaving the granular particles of stone partly exposed. In general this is done by washing the surface with a weak acid solution, then with clean water, and finally with an alkaline solution to neutralize any effects of the acid. In the finished work it is difficult to detect that the material is not natural stone, except by close inspection. The stone is crushed to pass through a sieve of 10 to 30 meshes per sq. in., according to the character of finish desired, and enough water is used to make a soft plastic mixture.

PLASTERING.—Plastering as a method of finishing concrete surfaces deserves mention for the purpose alone of calling a warning against its adoption. It is practically impossible to apply

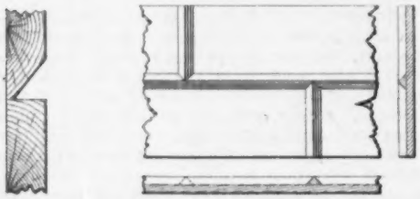

Fig. 1. Joint for Sheathing for Forms for Concrete Work.

Fig. 3. Form for "Marking" Concrete to Resemble Ashlar Work.

mortar in thin layer to a concrete surface and make it adhere for any length of time, and when it once begins to scale off the result is a surface many times worse in looks than the unfinished concrete that it was intended to render more sightly.

PEBBLE DASH FACING.—An effective surface finish for certain classes of concrete work can be secured by using rounded pebbles in place of the usual aggregate for the surface layer of concrete, and then, while the concrete is soft, removing the mortar between the pebbles by wire brushing until approximately half the pebbles is exposed. The following specification for this style of facing was employed in constructing a small concrete road bridge in the National Park at Washington, D. C.:

The concrete, which will be on the exterior faces of the bridge and the parapet walls for a thickness of 18 ins., will be made of gravel and rounded stone varying in the concrete below the belting course between 1½ and 2 ins. in their smallest diameters. This gravel will be mixed in the concrete as aggregate instead of broken stone. The mixture will consist of one part Portland cement, two parts sand, and five parts of aggregate. The parapet walls will be made in a similar manner, with the aggregate composed of gravel not exceeding 1-in. in its smallest diameter. When the forms are removed the cement and sand must be brushed from around the face of the gravel with steel brushes, leaving approximately half of the gravel exposed.

In this work it was found by test that at the age of 12 hours the concrete was not sufficiently set to hold the pebbles from being torn out by the brushing, and that at the age of 36 hours it was too hard to permit the brushing to remove a sufficient depth of mortar without undue labor. At 24 hours' age the brushing proved most successful.

TOOLED SURFACES.—A method of finishing concrete surfaces which is preferred by many experienced engineers is to dress the concrete after it has hardened by means of hammers or pointed chisels. The process is exactly analogous to stone dressing, and any of the forms of finish employed for cut stone can be employed equally well for concrete. In connection with tooled surfaces it is common to mold the concrete to represent ashlar masonry by means of horizontal and vertical V-shaped depressions formed as shown by the drawings of Fig. 3. This style of finish has been extensively employed by Mr. E. L. Ransome, who gives the following directions for securing it: In imitating rough dressed work the mold is removed from the concrete while it is yet tender, and with small, light picks the face is picked over with great rapidity, an ordinary workman finishing about 1,000 sq. ft. per day. For imitations of finer-tooled work, the concrete should be left to harden longer before being spalled or cut, and the work should be done with a chisel. Most natural stone, and especially granite, make excellent material for the faces, but ordinary gravel will do. Whatever is used, let it be uniform in color and of an even grade. When a very fine and close imitation of a natural stone is required, take the same stone, crush it and mix it with cement colored to correspond. The finer the stone is crushed the nearer the resemblance will be upon close inspection; but for fine work it is generally sufficient to reduce the stone to the size of buckshot or fine gravel.

MASONRY FACINGS.—A facing of masonry is often employed on reinforced concrete arch bridge, and is a very satisfactory solution of the problem of surface finish for such structures. Masonry facing may be of any style of stonework which is used for true masonry arches and coursed ashlar, random, rubble and boulder masonry facings have all been employed. Exactly the same care should be exercised in selecting stones and laying them up into arch ring and wall, cornice and parapet as if the structure were entirely of masonry. Beyond this, the most important feature to be observed is the close bonding of the masonry facing to the concrete backing. To insure this, there should be a liberal use of stretchers reaching well into the backing, and these can be supplemented with metal cramps to the advantage of the work in many instances. For facing the arch ring the stones should be cut to true voussoir shape, and laid quite as perfectly as if they were a part of a true voussoir arch ring. The soffit of the arch ring is not stone-faced. In place of stone, a brick facing may be employed.

The following specifications for stone and brick facing, which were prepared by Mr. Edwin Thacher, M. Am. Soc. C. E., to control work constructed by him, gives a fine idea of the requirements of high class work of this character:

Stone Facing.—If stone facing is used, the ring stones, cornices and faces of spandrels, piers and abutments shall be of an approved quality of stone. The stone must be of a compact texture, free from loose seams, flaws, discolorations, or imperfections of any kind, and of such a character as will stand the action of the weather. The spandrel walls will be backed with concrete, or rubble masonry, to the thickness required. The stone facing shall in all cases be securely bonded or clamped to the backing. All stone shall be rock faced with the exception of cornices and string courses, which shall be sawed or bush hammered. The ring stones shall be dressed to true radial lines, and laid in Portland cement mortar, with ¼-in. joints. All other stones shall be dressed to true beds and vertical joints. No joint shall exceed ½-in. in thickness, and shall be laid to break joints at least 9 ins., with the course below. All joints shall be cleaned, wet and neatly pointed. The faces of the walls shall be laid in true lines, and to the dimensions given on plans, and the corners shall have a chisel draft 1-in. wide carried up to the springing lines of the arch, or string course. All cornices, moldings, capitals, keystones, brackets, etc., shall be built into the work in the proper positions and shall be of the forms and dimensions shown in plans.

Brick Facing with Concrete Trimmings.—The arch rings, cornices, string courses and quoins, shall be concrete faced as described above, the arch rings and quoins being marked and beveled to represent masonry. The piers, abutments and spandrels shall be faced with vitrified brick as shown on plans. The brick facing shall be plain below the springing lines of the arches, and rock-faced above these lines. All rock-faced brick shall be chipped by hand from true pitch lines. All brick facing shall be bonded as shown in plans, at least one-fifth of the face of the wall being headers. The brick must be of the best quality of hard-burned paving brick, and must stand all tests as to durability and fitness required by the engineer in charge. The bricks must be regular in shape and practically uniform in size and color. They shall be free from lime and other impurities; shall be free from checks or fire cracks, and as nearly uniform in every respect as possible; shall be burned so as to secure the maximum hardness; so annealed as to reach the ultimate degree of toughness; and be thoroughly vitrified so as to make a homogeneous mass. The backing shall be carried up simultaneously with the face work, and be thoroughly bonded with it.

The use of boulder facing will ordinarily be limited to structures of special character, and its success will depend very largely upon the care with which the stones are selected, their size and their arrangement in the structure. In constructing a boulder-faced concrete arch at Washington, D. C., the following requirements were specified for the facing:

The term boulder stones here is meant to cover loose rock which shall be hard, sound, durable and of a quality to be approved by the Engineer, whose edges have become weathered or water-worn, or both, and are more or less rounded. It is the intention to obtain a decidedly rustic effect on the facing, and to that end extreme care must be taken in the selection of the stones, and only mechanics who show an aptitude for this class of work shall be employed. No tool marks or fresh fractures will be allowed on the showing faces.

The boulder face of such stone shall project at least 2 ins. beyond the neat lines of the bridge and this projection shall not exceed 15 ins., nor shall it be greater than one-half the least horizontal dimension of the stone. All joints shall be scraped and brushed clear of mortar to the depth indicated by the Engineer. The mortar shall consist of 1 part Portland cement and 2 parts sand. The backs of all boulders shall be plastered with a layer of mortar as specified, at least ¼-in. thick, immediately before ramming the concrete against them.

The arch stones have a depth of between 3 and 4 ft., a width of not less than 18 ins. nor more than 36 ins., their length shall alternately be 18 ins. and 24 ins.; all dimensions to be measured exclusive of the projections beyond the neat lines. The joints shall be dressed so as not to exceed 1½ ins. at any point for at least two-thirds their depth and two-thirds their length, and as much more as the stones will admit. Each arch stone shall be cramped to the adjacent steel girder by means of a wrought iron cramp made from ⅝ × ⅝-in. bar, the cramps to reach at least 2 ins. into each boulder, to be cemented into them and securely cramped to the top of the girder. The outside girders shall be cramped to the adjacent girders by two wrought iron cramps made from ⅝ × ⅝-in. bar (in construction we used ⅝ × ¼-in. as it bent cold without fracture).

No dressing will be required on the stones used in abutments, spandrels and wing walls of the work, but only well shaped boulders, laid on their broadest bed, will be allowed. Dressing will be permitted on such stones as cannot be properly bedded without it.

The parapet walls will be a continuation of the spandrel and wing walls. The boulder stone must reach entirely through the walls.

CAST CONCRETE SLAB VENEER.—In constructing the arch bridge at Soissons, France, the faces of the arch ribs and the spandrel facing was formed of slabs of concrete-steel, molded separately and set in place like stone veneer, with the remainder of the concrete forming a backing. An essentially similar construction was employed in Chicago, Ill., in 1902, in constructing a number of recreation buildings in one of the city parks. In the last example mentioned, the slabs were cast face down in wooden molds; the mode of procedure being as follows: A layer of mortar composed of 1 part cement and 2 or 3 parts of finely crushed stone was first placed in the bottom of the mold to a depth of from ½ in. to 1 in.; on this bed of mortar a 1-2-4 concrete, with ½ to ¾-in. stone, was placed to the thickness desired and carefully rammed. After hardening the blocks were removed from the molds and set aside to season until they were placed in the structure.

The construction of the slab veneer for the Soissons Bridge was as follows: For molding the arch rib facing a smooth level platform or pavement of concrete was constructed on an adjacent level piece of ground. This molding platform was large enough to permit the arch ribs to be delineated to full size on its surface. To prepare the mold the platform was covered smoothly with gunny cloth, held down by battens, which also served to outline the extrados and intrados of the arch rib. Radial strips of wood were then placed to divide the mold into voussoir-like sections. A thin bed of mortar was placed on the bottom of the mold and on this was laid four reinforcing bars, one near and parallel to each edge of the voussoir being molded so as to intersect at the corners. Under these bars at several points wire stirrups were looped with their free ends projecting upward. The metal was then covered with a rich concrete of fine stone laid on the mortar bed and compacted so that the total thickness was about 3 ins. When hardened,

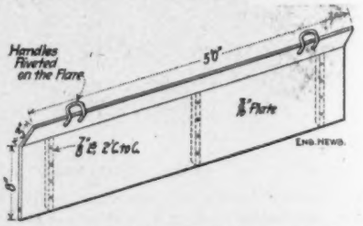

Fig. 2. Form for Applying Mortar Facing to Concrete Work.

the product of the mold was a set of voussoir-shaped slabs with smooth faces and edges and a rough back, with a number of projecting wires. In construction these facing slabs were set in place with mortar joints and backed with concrete. For the spandrel wall facing the slabs were cast in rectangular molds in exactly the same manner. The engineers of the Soissons Bridge remark that the use of this cast concrete veneer enabled a considerable reduction of expense for forms and assured a surface finish of pleasing appearance.

MOLDINGS AND ORNAMENTAL SHAPES.—The finishing of concrete structures in many instances comprehends the construction of mold-

lings and ornamental shapes for cornices, corbels, medallions, keystones and other architectural parts. These may either be molded in place by suitable construction of the stationary forms or they may be cast separately in portable molds and set in place in the structure as would be cut stone. Panels of simple form or plain cornice moldings can usually be molded in place without great trouble and expense, but in constructing corbels, complicated moldings, balusters, etc., particularly where one pattern is duplicated a number of times, time and expense will usually be saved by casting them separately or in sections, and afterwards erecting the separate pieces in the structure.

The casting of ornamental shapes in concrete may be accomplished either in sand molds or in rigid molds of wood, metal or plaster of paris. Some very handsome work has been recently performed by sand molding. The mode of procedure followed in making concrete castings in sand varies somewhat in practice, but it is substantially as follows: A pattern of the shape to be cast is first made in wood and to the exact size required, since no allowance for shrinkage is necessary. The pattern is then molded in sand in flasks exactly as is done in casting iron. The mixture used usually consists of cement and finely crushed stone of about the consistency of cream, and this is poured into the mold by means of a funnel and T-pipe. The excess water in the mixture soaks into the sand and serves to keep the casting moist during setting. Generally the casting is left in the mold for three or four days, and is then removed, and the projecting pins, if any, are cut off. The cast stone may be used immediately in the work, but it is preferable to let it season and harden for a fortnight or more before using. The product of these sand molds has an unusually attractive surface texture. Sand molding is particularly advantageous when balusters, corbels, medallions and intricate moldings have to be cast, but for plain cornices and facing slabs it is generally as cheap and convenient to use wooden forms.

EFFLORESCENCE.—The leaching out of certain lime compounds and their deposition on the surfaces of concrete work are quite frequently the cause of the uneven color of such surfaces. In relation to this source of discoloration Mr. Clifford Richardson, director of the New York Testing Laboratory, says:

> It is primarily due to variations in the amount of water in the mortar of which the cement is composed. It will be readily understood that where any excess of water is used segregation of the coarse and fine particles will take place with a resulting difference in color. Where a large amount of water is used the concrete is more porous and the very considerable percentage of free lime liberated from the Portland cement in the course of setting, is more readily brought to the surface at such a point. . . . The amount of water in a concrete, the face of which is to be exposed, should be neither too small nor too large, but such a concrete should certainly not be dry or the exposed face will be honeycombed. . . . Where the greatest care is used as to the amount of water added to the mortar and to prevent its loss, and where separation of the mortar from the broken stone is carefully avoided in depositing the concrete and in ramming it, the exposed surface after the removal of the molds is fairly uniform in color. . . . A more uniform color will always be obtained where some puzzolanic material is ground in with the cement such as slag or truss. This hydrated silicious material combines with the lime, which has been liberated and prevents it washing out on the surface. . . . Exactness in the amount of water used in the concrete, where the elimination of the strain caused by the free lime is considered desirable, the addition of some substance containing silica in an active form are the two steps to be taken to produce a concrete step which should present a uniform color and a pleasing appearance.

The measures whose adoption are recommended in the quotation just made are designed to prevent the occurrence of efflorescence by adopting certain precautions in the materials and workmanship of the original construction. Their adoption, however, if it gives the success that Mr. Richardson anticipates, is obviously the way to get at the root of the trouble, but such action involves a degree of skill and watchfulness in constructing concrete work which is difficult of attainment under ordinary conditions of engineering construction, and which if attained will add materially to the cost of construction. They have the further objection that a special mixture of cement is required about which our information is not entirely certain. In default of preventative measures which recommend themselves to general use the engineer who encounters the trouble of efflorescence must overcome it by remedial measures. There are a number of these available. The most practical ones are the washing of the discolored surfaces by solutions which will remove the incrustation, or the removal of the original surface by dressing it down with hammers or tooling of some sort.

The manner of dressing down concrete surfaces to eliminate surface imperfections is discussed in a previous paragraph. The following account of the method of dressing a concrete steel bridge at Washington, D. C., gives instructive data as to this mode of procedure: The bridge in question had a mortar facing, and after this was completed a heavy rain caused the entire north facade to become discolored by efflorescence. This discoloration was not uniform, but in streaks and blotches, of a white color, which, after weathering a short time, turned into a dirty yellow. To clean the bridge trial was first made of water and wire brushes, but after a little work this method was considered impracticable owing chiefly to its cost, which was estimated at $2.40 per square yard. Washes of dilute hydrochloric acid, of dilute acetic acid and of dilute oxalic acid were then tried in conjunction with ordinary scrubbing brushes. The hydrochloric acid wash proved the best, and the acetic acid wash came next in efficiency. The wash finally adopted consisted of a solution of one part hydrochloric acid and five parts water. This was applied vigorously with scrubbing brushes, water being constantly played on the work with a hose to prevent the penetration of the acid. One house cleaner and five laborers were employed on the work, which cost 60 cts. per square yard. This high cost was due largely to the difficulty of cleaning the balustrades; it was estimated that the cost of cleaning the spandrel and wing walls did not exceed 20 cts. per square yard. The cleaning was thoroughly satisfactory. Some of the flour removed by the brushes was analyzed and found to be silicate of lime.

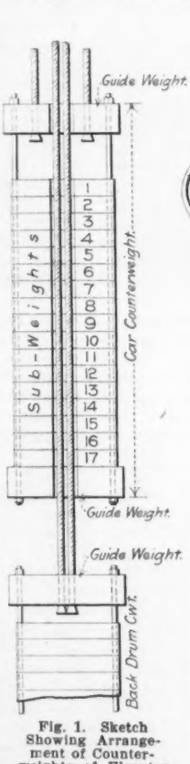

Fig. 1. Sketch Showing Arrangement of Counterweights of Elevator at 270 Mercer St., New York.

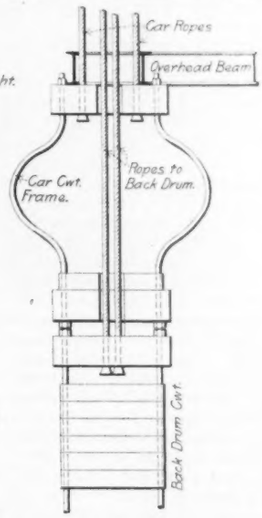

Fig. 3. Sketch Showing Manner of Failure of Car Counterweight Frame.

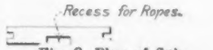

Fig. 2. Plan of Sub-Weights in Car Counterweight.

SOME RECENT ELEVATOR ACCIDENTS.

By Edward Van Winkle,* Assoc. M. Am. Soc. C. E.

On Monday, Aug. 15, 1904, an elevator accident occurred at 270 Mercer St., New York City, in which two lives were lost. The lower automatic limit stop of the elevator failed to work, but the elevator arrested itself a little below the first floor. The hoisting motor, continuing to run, raised the drum counterweights above their normally highest position, and forced the car counterweights into the overhead work. This had the effect of springing the vertical side rods of the car-counterweight frame (see Fig. 3), and allowed sixteen sub-weights to drop into the hoistway.

The elevator was installed in the fall of 1895 by the Sprague Elevator Co., and was known as Type "Z" electric drum machine. The drum is 36 ins. in diameter with 34-in. face, to take care of a rise of about 145 ft. from first floor to the top. The machine was designed to develop a car speed of 150 ft. per minute, and with that speed the maximum temporary load on the ropes should not exceed 5,000 lbs.

Had Section 10 of the Regulations for the Construction, Inspection and Operation of Elevators issued by the Bureau of Buildings, Borough of Manhattan, New York City, been complied with, the accident might not have been at all serious. Quoting this section:

> All counterweights shall have their sections strongly bolted together and shall be so situated that they cannot fall on any part of the elevator or machinery. Where weights run in the same shaft as the car they must be protected with a substantial screen of iron from the top of rail to a point 15 ft. below. There shall be no less than 3 ft. clearance between the top of the counterweight and the under side of overhead beams when car is resting on the bumpers.

One realizes that this section was incorporated in the laws above referred to to take care of just such an emergency as the one in question. Referring to the illustrations: Fig. 1 is a sketch of the counterweights which met with accident. The car counterweight consisted of a frame made up of two guide-weights and two round uprights. The seventeen sub-weights were held in place only by the vertical rods fitting the open slots in the ends as shown in Fig. 2, and not by bolts or rods as required by the regulations. Fig. 3 illustrates how the drum weights forced the uprights of the car counterweight frame outward allowing sixteen of the sub-weights to fall on the struggling mass of humanity in the car at the bottom of the hoistway.

Fig. 4 shows the proper form of compound counterweight. Through each sub-weight pass two rods (12 ins. on centers) which firmly fasten them together. It will be noticed that every fourth weight is a guide-weight which also adds to the strength of the weight as a whole. Had the weight been thus constructed the accident could not have happened as it did. Furthermore, if the counterweight screen had been in place, in all probabilities the passengers would have had time to get out of danger before the weight fell.

If the weight had been constructed as shown in Fig. 4, and the counterweight screen as required by law, been in place, the drum counterweight ropes would have (possibly) pulled out, allowing the drum weight en masse to fall to the bottom of its hoistway; in this case it would have gone down into the engine room and no loss of life would have occurred. Details in design and construction are of utmost importance, and it takes accidents like this to open the eyes of the average layman.

Upon the safety grip on the car, the automatic top and bottom limits, the slack-cable device, and a positive brake mechanism, every elevator builder relies to meet the element of danger which he knows exists in every other part of his machinery; and great care and attention should be paid to these parts by the engineer in charge at the building. Periodical tests of the top and bottom limits with car at full speed should be made, and the brake should be always kept in perfect adjustment and alinement.

The writer's attention was called only the other day to an accident somewhat similar to the preceding. The elevator in question is of the electric drum type, with shipper rope and wheel control, manufactured bp the Salem Elevator Works, and installed by the Bradshaw Elevator Works in the Siebrecht Bldg., 425 Fifth Ave., New York City. The machine was designed to drive the car with a load of 2,500 lbs. at 250 ft. per min., and was equipped with an ordinary slow speed limit and gravity brake which at best was insufficient to

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properly take care of the work required. The car was on its up trip, carrying the operator and one passenger, when the shorter rope broke, leaving the operator helpless and dependent upon the upper automatic limit to stop the machine. The car continued up the hoistway, striking the overhead work, the lift ropes pulled out of their sockets and allowed the car to fall to the basement,

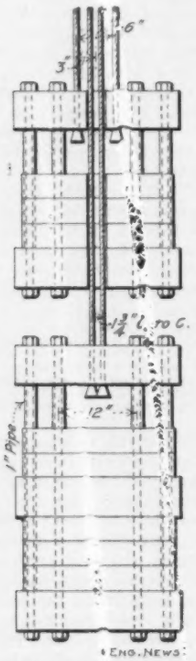


Fig. 4. Proper Arrangement of Double Counterweight with Binding Rods.

slightly retarded by the safety device which failed to work properly.

Upon careful examination of the machine, the writer found the brake-band slack on the pulley, which would have allowed the car to go into the overhead work even if the automatic limit was properly set. It must be understood that the car was running overbalanced, the machine running with gravity, giving considerable momentum to the large diameter armature which could not be overcome with a slack brake.

If the car had been supplied with a proper safety device, the car would not have fallen into the basement and the accident would not have been so serious. The type of safety that failed is the well-known wedge type, and is generally considered to be an inferior style of safety for the reason that if it operates properly it stops the car too suddenly and the abrupt stop is almost certain to injure the passengers. In this case the wedge was smooth and when sprung into position did not take hold sufficiently strongly to stop the car.

When the car fell the car counterweights were driven into the overhead work, but, being properly tied together and protected by the screen required by the building laws, they did not separate and add to the disaster—as in the first case cited.

A stupid piece of carelessness was discovered to exist on Friday last, when an elevator fell in the factory of Frederick R. Wood & Sons, No. 219 West 19th St., instantly killing the superintendent. The elevator was a typical hand-power wagon-hoist, found in most of the stables and carriage houses in the city. The platform was guided on four maple corner guides, and counterbalanced by a weight equal to that of the car. The hoisting rope of manila winds itself upon a large drum at the top of hoistway when power is applied with a hand-rope, either by man power or by two traction sheaves which are arranged for the purpose of gripping the rope and by power raising or lowering the load. A band-brake mechanism is employed to hold the car at the floors when loading and unloading.

Absolutely no precaution has been taken for the safety of this elevator, even though there is seldom a load raised or lowered but what is accompanied by one or more passengers. No enclosures or gates are in place at the landings, and the only way to go from the front of the building to the rear is by passing under the elevator car, or over its platform when the car is at the bottom floor.

On the day of the accident the car was at the second story. A truck was being wheeled on the car, but it proved to be too heavy for the band-brake, allowing the car to fall to the first floor. At the time Joseph Smith, the superintendent, happened to be walking under the elevator, and he was instantly killed.

Is human life of less value in such a place than it is in an office building? Should men employed in these places be compelled to jeopardize their lives in this manner?

It is a well known trade fact that safety has no consideration whatever in this class of elevators. The purchaser does not want it, will not pay for it, and there are plenty of elevator companies that will give him exactly what he wants at his price. Is it anybody's business to put a stop to this negligence?

These accidents recall to mind afresh the operation of the building laws in New York City. The conditions of the past and primitive art of the construction of elevators were not as dangerous when the car speeds were less than 100 ft. per minute as they would be with the much higher speeds of to-day. The third case above cited is an instance of the dangers inherent in primitive construction. Still, even in those early times they were recognized as being dangerous, although no means was discovered then to rectify them. The present increased speed of elevators and their more universal use has brought forth means of eliminating most of the former dangerous elements. This has been fully recognized by the Building Department, which has framed adequate laws to avoid some of these dangers, such as those revealed in the Mercer St. accident. Unfortunately, however, the Building Department only insists that these safeguards be taken with *new* elevators, a position which is absolutely (if not criminally) inconsistent with the functions of a department whose only duty is to protect the lives and property in the territory over which it is supposed to have full control.

What is the cause of this apparent leniency on the part of the Building Department? Do they fully appreciate that it is important to have old elevators as safe as new elevators; have they insufficient power to draft and enforce regulations which they know are necessary; or are they so considerate of the owners that they do not wish to burden them with the expense to make their elevators safe? It is, of course, interesting to note the cause of catastrophes which involve much loss of human life, and to suggest remedies for the prevention of such further disasters; but it has come to be proverbial that no accident, whether it involves loss of one or of one thousand human lives, has any more than a mere passing interest to the minds of the public of which every individual is daily menaced with like dangers. The responsibility for applying the lessons taught by such catastrophes must, therefore, lie with the public authorities.

For example, the Mercer St. accident is a specific case of one elevator in the Borough of Manhattan that was known by the Bureau of Buildings and the insurance inspectors to be dangerous. What excuse have either to offer for the accident that has passed, and what remedy do they propose for avoiding similar disasters on thousands of elevators where similar dangers exist and of which, no doubt, they have full knowledge?

The accidents above cited all occurred in the Borough of Manhattan, New York City, and correspondingly the comments made upon them are directed at that city. But substantially the same comments, illustrated by substantially parallel cases, might be directed at any other large city in this country. Indeed, the administration and supervision of elevators in New York City is, probably, much better than anywhere else in the United States.

THE FIRST AMERICAN SINGLE-PHASE RAILWAY IN COMMERCIAL OPERATION; THE GENERAL ELECTRIC SYSTEM ON THE BALLSTON LINE OF THE SCHENECTADY RY. CO.

The study and development of the single-phase alternating-current railway motor during the past two years have been so active that this machine has become the most interesting figure in the field of electrical engineering. Both Europe and America have contributed to this work, and on both continents were results of high promise secured. Yet the actual realization of that promise by the opening to traffic of a single-phase line remained ever a little distance in the future. Here in America, in particular, several unfortunate happenings interposed to delay the commercial operation of at least two distinct single-phase railways, designed to be equipped with radically different types of motors. Finally, on Friday last, Aug. 19, 1904, a third line, using motors differing from either of these two, was exhibited in commercial operation at Schenectady, N. Y., after it had already been run in public service for a full week. The equipment operated perfectly, and every indication was that the system used is in condition for immediate application to electric

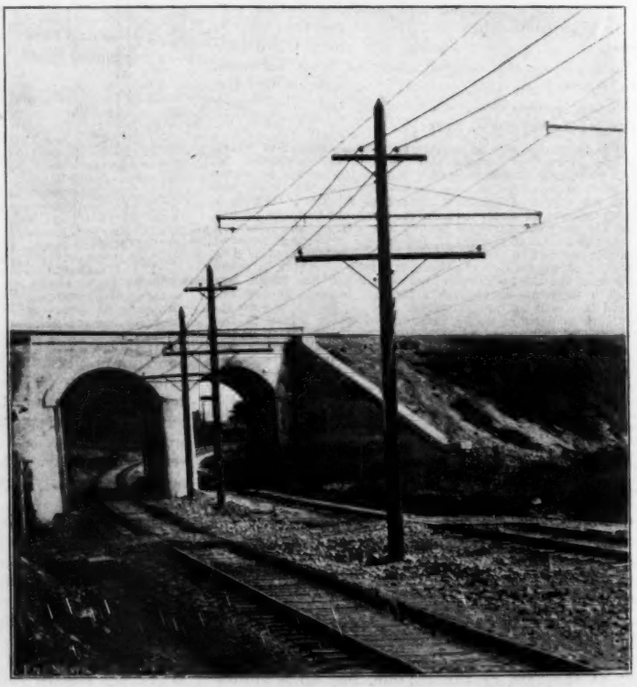


FIG. 1. OVERHEAD CONSTRUCTION ON BALLSTON LINE, SCHENECTADY RAILWAY CO., SCHENECTADY, N. Y.
(Direct-Current Central Trolley Wire. Alternating-Current Side Trolley Wire.)

street and interurban railway work generally. The exhibition took place on the Ballston line of the Schenectady Railway Co., a distance of 15 miles from Schenectady to Ballston Spa. It was witnessed by a representative of Engineering News in company with a party made up mainly of representatives of the engineering press at the invitation of the General Electric Co. of Schenectady,

N. Y., who designed the system and equipped the line. The Ballston line is the first alternating-current railway in regular service carrying passengers, in this country.

The principal characteristic of the system employed on the Ballston line is the use of series motors. These motors are exactly similar in electrical nature to the series motors which are standard in direct-current railway work, but have several important modifications in construction to fit them for operating with alternating current. Such motors have been designed in Europe by Dr. Finzi, of Milan, Italy, and in this country by the Westinghouse Electric & Mfg. Co. The General Electric motor differs from these in the means used for securing efficient action with alternating current. The nature of these means is of great importance in determining the efficiency and suitability of the machine as a railway motor. But whatever the means, the series motor inherently has the very valuable property that it is capable of working with direct current as well as with alternating.

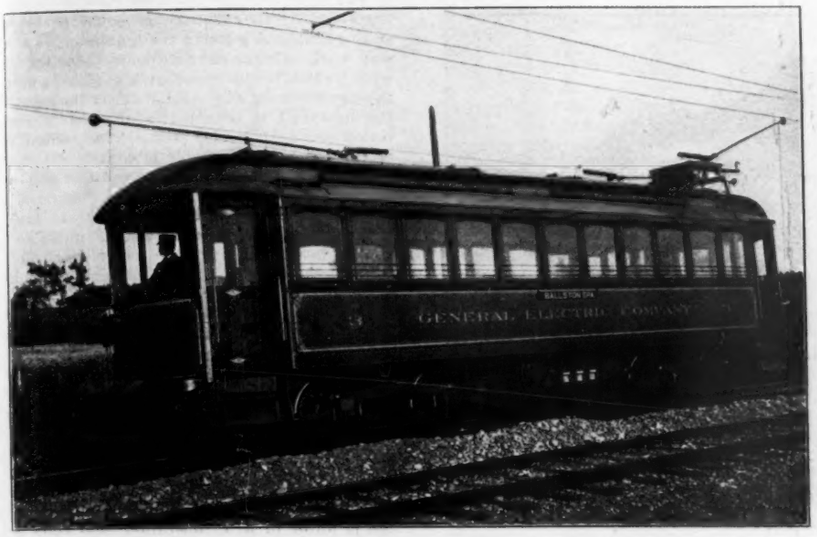


FIG. 2. SINGLE-PHASE ALTERNATING-CURRENT CAR, EQUIPPED FOR OPERATING WITH EITHER DIRECT OR ALTERNATING CURRENT.

This property can be put to excellent use for the purpose of operating a car over a line which has alternating current on part of the system and direct current on another part. Such a case would be, for example, an interurban line running over direct-current lines within the limits of cities and towns, where the high voltage which makes the alternating current of value would be undesirable. The Ballston line is of the character described. The car which carried the invited party ran over the direct-current section and the alternating-current section without any difference being apparent.

In order to operate a series motor on both direct and alternating current, the controlling mechanism, which constitutes a large part of the car equipment, must be such that it can be utilized for both kinds of current; otherwise two separate sets of controlling mechanism are required, whereby the bulk and weight of the whole equipment may be increased so much as to make the whole system economically impossible. The General Electric design avoids the latter disadvantage by employing the standard series-parallel control, using the same controller and the same resistance-grids for both kinds of current. The whole controlling mechanism and the accessory equipment are of thoroughly mechanical design, and, as far as can be judged now, introduce no complications which might lead to difficulties or accidents in operating. This will perhaps be better apparent from the description given farther on.

The great importance of being able to run a car over both alternating-current and direct-current lines appears from the following considerations. Electric railway motors in general use throughout the world are operated, as is well known, by direct current with a trolley voltage of about 600 volts. For heavy service and extended systems the cost of copper required at 600 volts becomes a serious item, and the need of a higher trolley voltage makes itself felt. The use of alternating current for the trolley admits of a higher voltage than is possible with direct current, as the voltage can be reduced by a transformer on the car to the potential required by the motors. The development of large power stations and transmission systems has been principally with alternating current, requiring numerous substations equipped with rotary converters or other commutating devices for changing the alternating current into direct current suitable for the operation of electric railways. Obviously there would be a great advantage for long lines, such as interurban railways, in a railway motor equipment that could be operated from an alternating-current high-voltage trolley and without the necessity of intermediate commutating devices. A large part of the construction cost could then be saved, and interurban traction would become still cheaper, while the question of "electrifying" main-line railways would take on a new aspect.

But in city streets it would be highly undesirable, perhaps dangerous, to use a high-voltage current directly on the trolley wire. On the other hand, if a low-voltage alternating-current system for cities be considered, the direct-current system has a distinct advantage over an equivalent low-voltage alternating-current system: with the A. C. system using a trolley and track return, there is an inductive drop of voltage in the trolley and rails, with an additional loss in the rails due to eddy currents and hysteresis. Measurements made upon the Ballston line indicate an apparent trolley resistance of 1.3 times the ohmic resistance, and a rail resistance 6.55 times the ohmic resistance, as shown by the table below.

Comparative A. C. and D. C. Resistance of Trolley-Wire and Track, per Mile of Circuit.

	D. C. Resistance.	A. C. Resistance, 25 cycles.	Ratio. A. C. D. C.
Two trolleys in series..	.318 ohms	.417 ohms	1.31
One trolley and double track	.167 "	.259 "	1.55
Two trolleys and double track	.088 "	.155 "	1.76
Double track alone....	.0174 "	.114 "	6.55

This increased resistance with A. C. is a serious factor in low-voltage city systems; it makes it advantageous to use direct current on the relatively short length of city lines. Even aside from this, the fact that all present-day street railways are equipped for direct current makes it certain that they will be operated by direct current for years to come. Thus, the conditions of electric traction in the immediate future seem to be: alternating current at high voltage on the trolley outside of cities, where the distances are great, and the standard 600-volt direct current within the boundaries of cities. Now a most important factor in the success of interurban railways has been the possibility of running them into and through cities and villages, and this possibility must be provided for in any proposed system of electric traction. Unless it be possible to run the same cars over both the high-voltage A. C. and the low-voltage D. C. sections, a separate low-voltage A. C. trolley wire would have to be installed in cities merely to enable the interurban cars to enter. Our city railway systems, however, have so expanded and cover such a large territory that it would be very objectionable, on the score of first cost as well as of complication, to install such an additional distribution system.

The development of an alternating-current equipment able to run equally well over the whole of compound lines of the kind described, is, therefore, of very direct value. This is a main reason why the series motor has received so much study by electrical engineers. It explains, also, why the exhibition of a complete railway equipment in commercial state actually running over an interurban system with high-voltage A. C. on the main line and low-voltage D. C. at the city termini, is a subject of so much interest.

The Ballston line has a special characteristic in addition to those above alluded to. It is fitted with direct-current trolley wire throughout its whole length, and the majority of the cars now running over it are operated by direct current. The line has been open for traffic as a direct-current line for two months past, while regular alternating-current operation dates back little more than a week. The combination of two separate trolley wires for each track is made possible by a very neat form of overhead construction, which has much merit outside of this special case. This construction is described below.

The Ballston line is 15.5 miles in length, including 3.9 miles of city running in Schenectady over tracks equipped with direct-current trolley, and a short length of direct-current trolley at the Ballston end. The interurban section is double track on private right of way, 60 ft. wide, laid with 75-lb. T-rails, gravel ballasted, with maximum grade of 1.8%. Special attention has been given to the high-speed possibilities of the road, and no curve exceeds 4¼°.

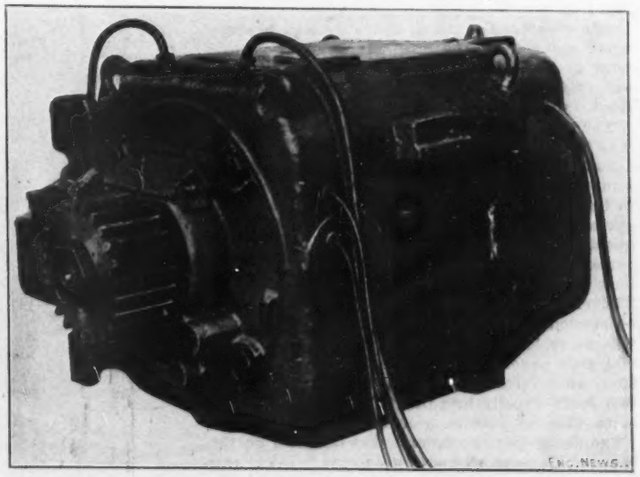


FIG. 3. COMPENSATED SINGLE-PHASE SERIES RAILWAY MOTOR; GENERAL ELECTRIC CO.

Center-pole bracket construction is used, there being two brackets supporting the two 600-volts D.C. trolley wires and a cross-arm supporting the 2,200-volt A. C. trolley wires (see Fig. 1). The center poles are 34 ft. long and are spaced 100 ft. apart, the A. C. and D. C. trolley wires being No. 000 grooved section with no feeders for the A. C. trolley and with a 500,000 circular mil feeder reinforcing the D. C. trolley. The D. C. trolley suspension conforms to standard bracket construction and presents no unusual features, while the A. C. trolley wire is suspended from a 'ongitudinal ⅜-in. steel catenary. The A. C. trolley is clipped to the catenary midway between poles and the catenary in turn is hung over porcelain insulators on wooden cross arms. The whole forms a construction of great flexibility with the further advantage of providing excellent insulation with standard porcelain insulators and eliminating the span wires adjacent to the trolley wire, thereby preventing the pole catching should the trolley wheel leave the wire. This method of trolley construction is well adapted to high-potential high-speed work in both its electrical and mechanical features.

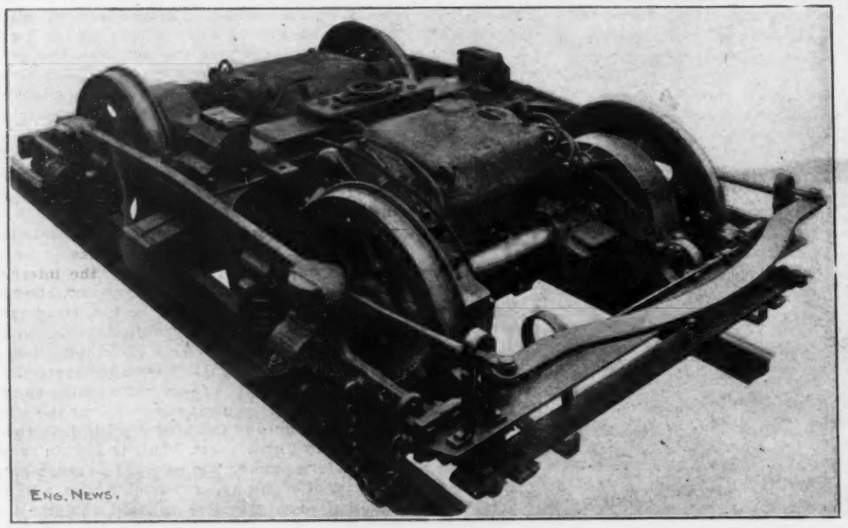


FIG. 4. BRILL 27 TRUCK EQUIPPED WITH TWO GENERAL-ELECTRIC SINGLE-PHASE SERIES MOTORS.

The resistance of the A. C. trolley wire is somewhat reduced by the steel catenary in parallel with it. The A. C. trolley wires are 5 ft. apart and 16.5 ft. above the track. The four 75-lb. track rails are tied together every 1,500 ft.

The present substation of the Schenectady railway is temporarily located at Ballston Lake. This substation is operated from the distributing system of the Hudson River Power Company, but owing to the fact that this system operates at 40 cycles, it became necessary to introduce a frequency changing device, and an inverted converter operated from the substation D. C. bus bars afforded the most ready means of obtaining 25-cycle current. The permanent substation will be erected at Ballston and the inverted converter will be replaced by a motor-generator set which will give better regulation than can be obtained from an inverted rotary converter. The substation feeds directly into the trolley circuit at 2,200 volts with no outside transformer substations.

The equipment throughout was designed on the basis of 25-cycle alternating current because this frequency is almost universally employed for high-tension distribution to rotary substations to-day, and it was desired to fit the new equipment as far as possible to the type of machinery in general use.

The single-phase car (see Fig. 2) weighs 30.4 tons, fully equipped but without passengers, and is geared for a maximum speed of about 43 mi. per hr. on level. The car, manufactured by the J. G. Brill Company, has a 32-ft. body, is 43 ft. over all, and has a seating capacity of 44 passengers. The body is mounted upon Brill No. 27 trucks having 6-ft. wheel base, each truck carrying two compensated motors. Each motor is equivalent to a 50-HP. direct-current motor, standard railway rating.

The General Electric alternating-current compensated motor consists of an annular laminated iron field with a distributed winding similar to that of an induction motor, and an armature provided with a commutator and similar in general mechanical construction to a D. C. railway motor armature. These motors are wound for 200 volts, are permanently connected two in series, and are fed from the 400-volt secondary of an 80-KW. air-blast step-down transformer carried on the car. A view of the motor is given in Fig. 3 herewith, while a truck with two motors mounted in place is shown in Fig. 4.

The distributed field winding is so disposed as to fully compensate for the armature reaction, so that the power-factor of the motor is relatively high throughout the range of operation. This type of motor is so designed that at the free running speed of the car, which is the condition most frequently met with in suburban work, the power-factor and efficiency are nearly at their maximum values. A high power-factor is desirable as it reduces the required capacity and cost of the generating and distributing systems, and more especially because it effects a material improvement in the regulation of the A. C. generators. For, unlike a D. C. system, which has a practically constant potential at the substation bus bars, irrespective of the load, the voltage drop in an A. C. railway system is accumulative up to and including generator and engine regulation. It is desirable therefore to maintain as good a power-factor as is consistent with good motor design, in order to limit the total drop of the system to a reasonable amount.

A set of motor characteristics is shown in Fig. 8 for both A. C. and D. C. running, respectively. It will be noted that the speed-torque characteristics for A. C. running are equal to those of D. C. running in meeting the requirements of railway work. Unlike the mutiphase induction motor with its practically constant-speed characteristic, the compensated A. C. motor varies its speed with the load and is thus better adapted to operate trains over an irregular profile. The commutation of the compensated motor is equally satisfactory when running A. C. or D. C., and this good commutation is secured by careful electrical and mechanical design without resorting to high resistance leads or other expedients liable to give trouble in case of sustained heavy overloads.

As already stated, the motors are permanently connected two in series. Fig. 7 shows how the two groups of two motors are connected by the controller for the various speeds. The diagram shows the series and parallel positions, with and without the starting resistances in circuit. Intermediate notches of the controllers are used, of course, to throw these resistances in and out of circuit by stages. It will be seen from Fig. 7 that the connection of the fields differs somewhat in the D. C. and A. C. operation, the fields of the two groups of motors being connected in parallel in the latter case. This is done because the voltage is lower in A. C. operation: 400 volts across the four motors as against 600 volts with direct current.

The controller used on the car is a standard General Electric "K.-28" series-parallel controller, and differs in no material particular from that of the ordinary street-car. Auxiliary to the controller is a device called "commutating switch," which resembles a small controller in appearance and construction. The commutating switch is mounted on the car-platform, alongside the main controller; it is connected in the main current leads, ahead of the controller, and has but two positions, one for D. C. and one for A. C.; it serves to connect up the main circuits in the proper manner for operating by the respective kind of current. The pieces of apparatus connected to this switch are: the motor fields, which as above noted, are somewhat differently connected for A. C. and D. C. operation; the primary and secondary of the main transformer which lowers the A. C. trolley voltage from 2,200 to 400 volts; the car lamps and a small step-up transformer, 400 to 600 volts, for supplying the lamps in A-C-operation; the motor of the air-compressor, which is

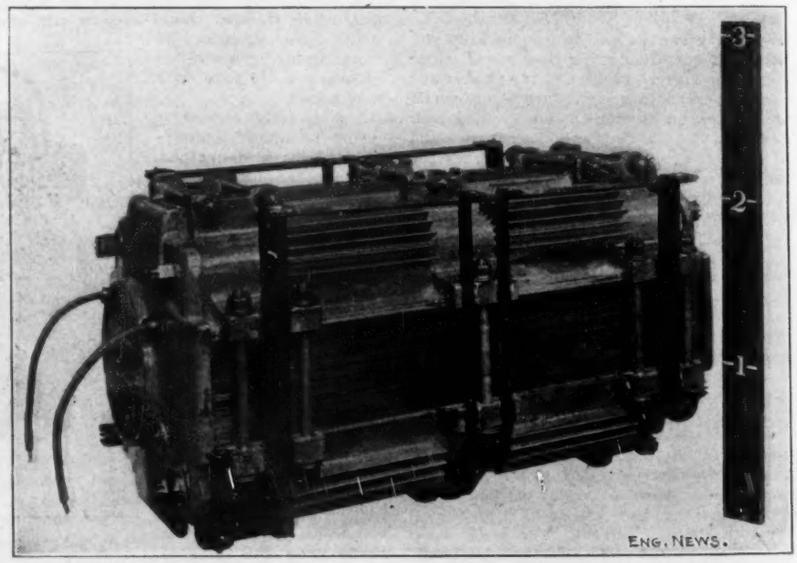


FIG. 5. STEP-DOWN TRANSFORMER ON CAR. 2,200 VOLTS to 400 VOLTS.

a small motor of the same type as the main motors; the line fuses, etc. The operation of this commutating switch consists merely in throwing a single handle, and therefore requires but a few seconds.

The commutating switch is interlocked with two main oil switches, Fig. 6, one being in the high tension A. C. and the other being in the direct current circuit. This interlocking is so arranged that only one switch can be closed at a time and the commutating switch can only be thrown when the oil switches are in the off position. Owing to the fact that on the Ballston line the A. C. trolley construction is off-center (4 ft. from center of track), while the standard city and suburban trolleys are directly overhead, it has been necessary to provide double sets of trolleys, one for A. C. and the other for D. C., hence the necessity of providing two separate oil switches and interlocking them with the commutating switch to prevent trouble should both trolley poles accidentally be up at the same time. Where center wire construction is used on both the city and suburban sections, the A. C. and D. C. trolley wires may be overlapped for a short distance to facilitate changing from one trolley to the other.

The interlocking is accomplished by using the same handle for the double oil-switch and the commutating switch. Normally the handle is on the oil-switch, and can be removed therefrom only in the middle position, when both halves of the oil-switch are open-circuited; it is then put on the commutating switch, the latter is thrown over, and the handle is then removed and reinserted in the oil-switch, to throw this over the remaining half of the motion. This arrangement seems to eliminate all chance of accident in changing from A. C. to D. C. or vice-versa.

The main transformer of the A. C. circuit (Fig. 5) 80-KW., is air-cooled, forced draught being obtained by the motion of the car itself. The transformer is suspended below the car floor and all primary leading in wires are carried in brass tubing which is grounded. Car lighting and heating is effected from the D. C. trolley in the standard manner, and from the A. C. trolley from the secondary of the transformer. Trolley poles and wheels are of standard design, the A. C. trolley pole being somewhat shorter as this wire is lower than the D. C. trolley. The base of the A. C. trolley is treated with vacuum compound and further insulated from the car body by composition insulators. The air compressor for the brakes and whistle is operated by a compensated motor which operates from both A. C. and D. C. circuits.

It is instructive to compare the performance of the compensated motor equipment when operated with A. C. and D. C. current. A set of speed-time runs is shown in the accompanying Fig. 9, the curves being taken over the same stretch of track with A. C. current and repeated with D. C. current. The D. C. speed-time and ampere-time curves are typical and require no particular comment. The A. C. run taken under exactly similar conditions over the same track illustrates what can be expected from series-parallel control with compensated motors. The rate of acceleration is somewhat lower in the A. C. run, hence requiring longer application of current to give the same speed. The shape of the speed-time curve also is characteristic of alternating-current motor work, that is a comparatively short time on the controller with a large amount of motor curve acceleration. The short period of fractional voltage running of alternating-current motors makes the method of their control of secondary importance and largely minimizes the economy of potential control over series-parallel control.

All speed-time runs taken on the Ballston line were made over a distance of 1.6 miles on tangent level track at an average speed of 32 mi. per hr., or a schedule speed of 29.5 mi. per hr., including 15-sec. stops. The compensated motor equipment has thus demonstrated its ability to make as high schedule speed as any suburban road now operating direct-current equipments under like conditions. The following constants apply to both sets of runs:

Comparative A. C. and D. C. Runs.

	D. C.	A. C.	C.
Length of run	1.6	1.6	miles
Weight of car	31.55	31.55	tons
Time	180	180	seconds
Average current power on	229	346	amperes
Average voltage	606	425	
Volt-amperes, full-speed on level	98	110	
Volt-amperes hrs. per ton-mile of given run	86.3	125.5	
Average speed	32	32	mi. hr.
Schedule speed, including 15-sec. stop	29.5	29.5	mi. hr.

The lower volt-ampere hours per ton-mile of the D. C. run is partly due to the better efficiency and power factor of the compensated motor when run on direct current, and partly due to the somewhat higher rate of acceleration, permitting some coasting and resulting in a more efficient speed-time curve. The difference in volt-amperes A. C. and D. C. depends upon the length of a given run and the values approach each other more nearly with a run of greater length. It will be noted that the compensated motors run the car at practically the same speed with 200 volts per motor A. C. and 300 volts D. C. This uniform speed is obtained by series-paralleling the fields, as shown in the diagram of connections, Fig. 7.

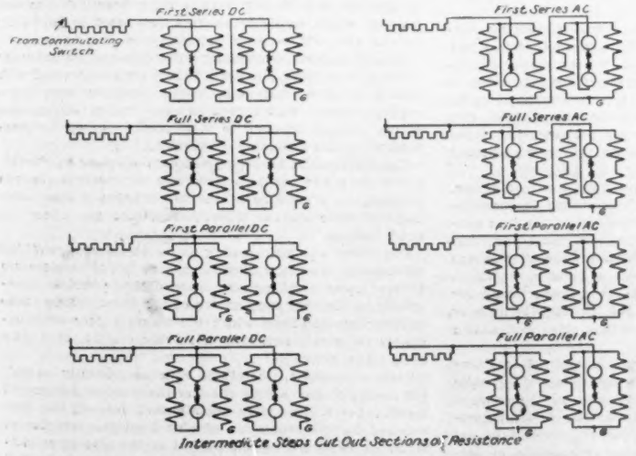


FIG. 7. DIAGRAM OF MOTOR CONNECTIONS FOR FOUR GENERAL-ELECTRIC SINGLE-PHASE MOTORS USED ON BOTH D. C. AND A. C. SERVICE.

RECAPITULATION.

Total length of line, 15.5 miles.
Length city running, 3.9 miles.
Length interurban portion, 11.6 miles.
Width private right of way, 60 ft.
Number of tracks, two.
Spacing of tracks, 13 ft. c. to c.
Weight of rail, 75-lb. T-rail.
Maximum grade, 1.8%.
Maximum curvature, 4° 15'.
Length center poles, 34 ft.
Spacing of poles, 100 ft.
Size trolley wire (A. C. and D. C.), No. 000.
A. C. trolley suspended from ⅝-in. steel catenary.
Ohmic resistance of trolley per mile circuit, .318 ohms.
Apparent resistance of trolley at 25 cycles, .417 ohms.
Ohmic resistance, one trolley and double track, .167 ohms.
Apparent resistance, one trolley and double track, at 25 cycles, .230 ohms.
Distance between A. C. trolleys, 5 ft.
Distance of A. C. trolley wire from center line of track, 4 ft.
Height of A. C. trolley above track, 16.5 ft.
A. C. trolley current, 2,200 volts at substation, 25 cycles.
Total weight of car without passengers, 30.4 tons.
Maximum speed A. C. and D. C., 43 mi. per hr.
Length of car, body, 32 ft.

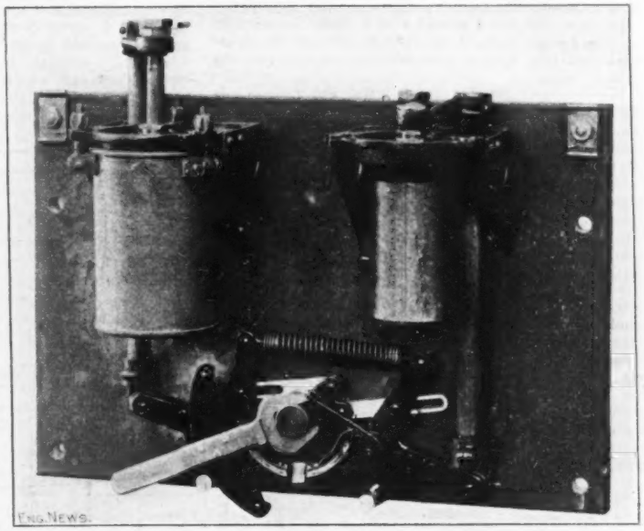


FIG. 6. SINGLE-POLE DOUBLE-THROW OIL SWITCH, DIRECT CURRENT AND ALTERNATING CURRENT. 200 AMPERES, 2,000 VOLTS.

(Right-hand switch has outer enclosing cylinder removed.)

Over all, 43 ft.
Seating capacity, 44 passengers.
Length wheel base, 6 ft.
Style truck, Brill. No. 27.
Equipment: Four GEA-604 compensated motors.
Each motor equivalent to 50-HP. D. C. motor, standard rating.
Voltage per motor, 200 volts A. C., 300 volts D. C.
Motors connected permanently two in series.
Type of controller, K-28 standard series-parallel controller.
Two A. C. and two D. C. trolleys per car.
Length specimen run, 1.6 miles. Average speed, not including stops, 32 mi. per hr.

NOTES AND OBSERVATIONS ON CAST-IRON.*

By J. E. Johnson, Jr.† M. Am. Inst. M. E.

The brief contribution of Mr. West‡ furnishes a text for the present paper, which will, however, take a wider range, warranted by the writer's somewhat unusual op-

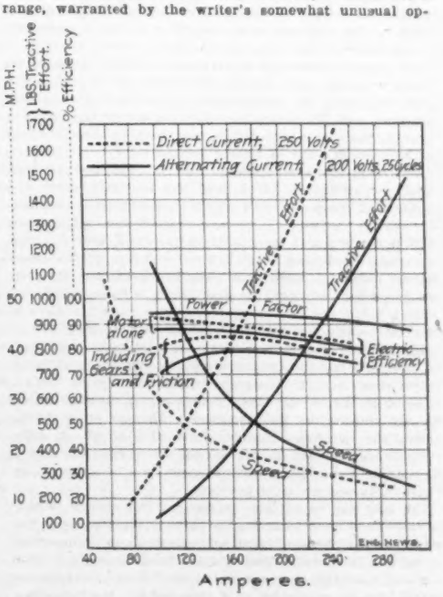


Fig. 8. Motor Characteristics of General-Electric Single-Phase Series Railway Motor.

Gear Ratio 71/19 = 3.74. Diam. of Wheels, 34 ins.

*From the Transactions of the American Institute of Mining Engineers.

†Manager Longdale Iron Co., Longdale, Va.

‡"Direct-Metal and Cupola-Metal Iron Castings," Eng. News, Vol. LI., p. 248.

portunities for the study of the practice of the foundry as well as the blast-furnace, and especially of the production of satisfactory castings from iron of a composition altogether unsuitable, in the opinion of the average foundryman, for that purpose.

Mr. West has observed that plates cast from direct-metal of a certain composition could be planed, whereas this would have been impracticable with cupola-metal of like composition; that furnace-metal has more "life" (i. e., fluidity, or a higher temperature) than cupola-metal; that it throws out much "kish," etc. And he suggests that the blast-furnace managers may throw further light on the greater softness of direct-metal castings. Perhaps such light may be furnished to some extent by the present paper.

The difference between cupola-metal and furnace or direct-metal is, first of all, in the lower average sulphur-content of the latter. It has been proved by experiment that iron increases in its content of sulphur to a considerable extent with each remelting. More than thirty years ago Fairbairn showed that a certain iron after remelting 18 times had only five-eighths of its initial tensile strength and stood one-third of its original deflection, though there had been a decided increase in both up to the twelfth remelting. He did not show the cause of these results, but they undoubtedly were due jointly to increase in the content of sulphur and combined carbon.

It is easy to calculate that, if iron be remelted with a coke containing a normal quantity of sulphur, say 1%, with a melting ratio of 10 to 1, and if only half of the sulphur goes into the iron, the increase in the sulphur-content of the latter will be 0.05%, which, according to the usual specifications, is the maximum amount the iron is permitted to contain, as it comes from the furnace.

The reasons for the higher heat of the furnace-metal are: first, that the ascending current of gases has a much lower temperature in the cupola than in the furnace because of the use of cold blast in the former. (This might be overcome in practice by the use of an excessive quantity of fuel, but it would require more than would be commonly supposed); and, second, more important, that in the cupola the iron is exposed to the hot gases for a much shorter period, and is consequently unable to approach as closely to the temperature of the gases as it does in the furnace, to say nothing of the temperature being lower in the former than in the latter.

Mr. West's experience in making workable castings from furnace metal of a silicon-content which if present in iron cast from the cupola would put machining out of the question, and his contention that the hotter the metal is poured, the softer the casting, may best be considered together, as they are so closely related.

The experience mentioned can be confirmed without doubt or hesitation. It is, and has been for years, the practice of the works with which I am connected to make, for repairs, as well as for new construction, all castings within the reach of their molding facilities, directly from a furnace producing "basic" iron, with the silicon guaranteed under 1% and the sulphur under 0.05%. The iron would perhaps average, the year round, sulphur 0.03% and silicon 0.7%; and yet there are comparatively few days in the year when the ordinary run of castings may not be made without fear of their being too hard to be machined. Of course, when the furnace produces white iron showing white clear through the pigs (which are cast in chills), it is necessary for the foundry to work on castings which do not require to be machined. On the other hand, should the iron contain much above 0.9% of silicon, difficulty is experienced in preventing holes and soft places in the castings, caused by the deposition of graphite or "kish"* during or after pouring.

The best way to mitigate or prevent this trouble, which is sometimes very annoying, is to pour the iron very hot when making pieces of small or moderate size. The effect is to chill the metal from a high heat by contact with the cold mold and reduce it to the solid form as quickly as possible, thus preventing, to a great extent, the formation of graphite while the iron is molten, which gives rise to the kishy places. The graphite formed after solidification is distributed more or less uniformly throughout the metal; whereas, if the metal is allowed to cool to some extent before pouring, graphite begins to form within it, and separates out at eddies and high points of the mold, with objectionable results.

It is impossible to discuss this subject satisfactorily without making use of the well-established fact that cast-iron being a member of the same series as steel, the principal effects in it are due, as in steel, to the quantity of combined carbon it contains. If the graphite, which is merely enmeshed in the cast-iron, were absent the latter would be, in fact, an impure steel, containing in general more silicon and (excepting Bessemer pig) more phosphorus than ordinary steel.

The acceptance of this view renders available for the study of cast-iron an enormous amount of material gathered from both practical and theoretical sources through many years, for the solution of problems presented by steel, in fact the work done upon steel furnishes a solid foundation for the study of cast-iron. This, indeed, seems quite the natural order, since it proceeds from the simpler to the more complex compound.

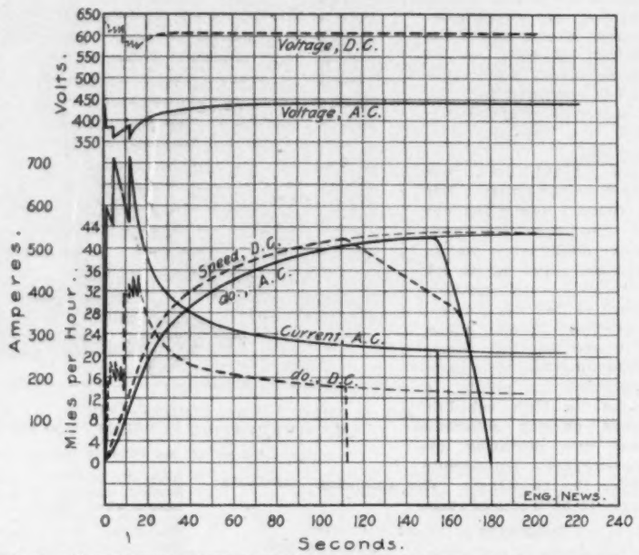


FIG. 9. SPEED-TIME, CURRENT AND VOLTAGE CURVES FOR GENERAL-ELECTRIC SINGLE-PHASE SERIES MOTOR.

(Curves for Alternating Current in Full Lines.)
(Curves for Direct Current in Dotted Lines.)

A chart of the "freezing-point curves" of the iron-carbon systems, such as those of Backhuis-Roozeboom and Roberts-Austen, shows that, with a pure cast-iron containing more than about 4.3% carbon, there is a range of temperature within which carbon must separate out in the form of graphite before solidification takes place; this range of temperature being closely proportional to the excess of carbon above the quantity mentioned, roughly 100° F. for each 0.5% carbon.

If, then, we had to deal with a pure iron containing, say, 5% of carbon, it is obvious that carbon in considerable quantity would have to separate out of the iron during cooling in the molten condition, and, naturally, that some of it would pass off into the air, especially in the ordinary operation of casting from a furnace, in which the running of the metal affords every opportunity for the liberation of this graphite. But, as there is little or no iron made containing 5% of carbon, this explanation alone is insufficient.

The diagram of freezing-point curves referred to shows that with all pure cast-irons the separation of graphite continues for several hundred degrees below the point of solidification; and it has been proved by direct experiment that silicon exercises a powerful influence in assisting or compelling the formation of graphite in this temperature-range (a fact also well known in practice); also that it lowers very markedly the temperature at which the separation of graphite can begin, and reduces the quantity of combined carbon with which the iron can be "in equilibrium."*

That this action of silicon on the formation of graphite persists above the point of solidification is proved clearly by its action in relation to suddenly cooled or chilled castings. It is well known that in the presence of more than 1.5% of silicon it is impossible to obtain any chilling action, and that, other things being equal, the strength of this action is inversely proportional to the quantity of silicon present below that amount.

So much being established, it may be taken as certain that silicon has the same effect in lowering the temperature and the percentage of combined carbon at which the cast-iron is in equilibrium above, as well as below, the point of solidification. It thus lowers the percentage of carbon above which graphite is forced to separate out from the still molten iron, and this accounts for the observed fact that, at a furnace running on foundry iron, the cast house is often full of kish, while at a furnace running on low silicon iron this is seldom seen, though the carbon content of the iron is as high (or higher) in the second case as in the first, and the iron may show a beautiful gray fracture when slowly cooled.

Many interesting facts have been developed as a result of using iron the composition of which is at the extreme limit permissible for foundry work. Castings are sometimes made from iron of which it is known that the machining will be, at best, barely practicable; yet it is necessary to save them if possible. For such cases a very slow cooling has proved efficacious; the castings are buried in hot sand and kept there over night, or even for a whole day, if they are large, and able to hold their heat for this length of time. Of course, the slow cooling is practically identical with the annealing of tool-steel, with the additional condition of the separation of graphite.

The reason for the absence of kish in ordinary cupola foundry work is that the metal, having a temperature considerably lower than that of furnace metal, has to pass in cooling through a much smaller part of that range above the melting point, within which graphite is compelled to separate out. Consequently there is little or no formation of graphite during the melted state, and hence no kish. This fact does not prevent the iron from being very graphitic when cold, because, as shown by the freezing point curve, the separation of graphite continues for several hundred degrees below the temperature of solidification.

It may be added that for each kind of cast-iron there is a maximum of carbon which it can contain dissolved when it "sets," though much of this carbon subsequently passes into graphite in the solid state. Any excess above this limit will be expelled in the form of graphite while the iron is still liquid. This maximum represents, in fact, the eutectic of iron and carbon for that kind of cast-iron. The limit of carbon for pure cast-iron is 4.3%, as already stated, and diminishes with progressive increase of silicon.

If, for convenience, iron containing more than this amount of carbon be called supercarbonized, or (adopting the scientific term) "hyper-eutectic," and any increase in temperature above the melting point of the eutectic be called "superfusion," it may be said that "kish" is formed when a supercarbonized or hyper-eutectic iron is superfused.

It may be said that kish is formed by molten iron, while graphite is formed by solidified iron, and it must be noted that kish can be formed only when the quantity of silicon present is sufficient to cause the carbon dissolved in the iron to supercarbonize it, or constitute a hyper-eutectic solution. Thus, when first-class basic iron is cast in sand it may have a most beautiful face and fracture which would cause it to be graded as No. 2 X; yet no kish will be seen flying in the cast house.

It is impossible to emphasize too strongly the influence of time in all these matters. This is well understood with regard to steel, but seems never to have been thoroughly realized with regard to cast-iron, in which most of the changes common to steel occur, as well as those incident to the formation of graphite.

The diagrams of freezing-point curves before mentioned, which show the cooling curves and the internal changes of steel, are always based on the condition of slow cooling, therefore do not directly represent the effects of quick cooling.

The effect of quick cooling is to transfer a condition represented in such a diagram by the initial temperature to the lower point on the same ordinate which corresponds to the final temperature of the quick cooling, thus introducing conditions which the diagram does not completely represent, especially if further cooling, at a slow rate, takes place.

Such a diagram, therefore, does not directly exhibit the results of the chilling effect of the mold on hot-poured metal. Yet it does show plainly that denying the time required for the separation of kish from the superheated metal increases the carbon content of the iron at solidification. This seems to me to indicate, further, that quick cooling raises the temperature of solidification, and consequently increases the range both of temperature and time during which graphite is formed after solidification. Hence a hot-poured iron tends to be less kishy and more graphitic than if poured at a lower temperature.

These conclusions are confirmed by practice. Hot-pouring to prevent the formation of kish has been mentioned already. It may be added that, of castings made from some kinds of furnace iron, those poured from the ladle are entirely free from kish, while those poured last from the same ladleful are so kishy as to be objectionable.

So far as I know, these general facts and their fundamental relation to the accepted theory of the general subject have not been published hitherto.

It is worthy of note, in this connection, that hot pouring

*"Kish" may be defined as consisting of loose particles of graphite, either thrown off into the air, or gathered on or near the surface of castings in aggregates so dense as wholly or largely to exclude the iron. In this paper, the term graphite, as distinguished from kish, means the particles more or less regularly disseminated and completely enclosed in the iron. In substance, apart from their mode of occurrence, the two are of course identical.

*"Equilibrium of Iron-Carbon Systems," G Charpy and L. Grenet, "American Manufacturer," June 6, 1902. "Metallographist," July, 1902.

tends to prevent the production of hard castings from relatively hard iron, and of kishy castings from relatively soft and kishy iron. This may explain the strong insistence of foundrymen upon "hot" iron.

Concerning the formation of graphite, it must not be forgotten that, as Prof. Howe has pointed out, the important question is not how much graphite is formed, but how much combined carbon is left.

Observations of irons habitually low in both silicon and sulphur content make much plainer the action of the latter element than do those of irons further removed from the chilling point by the presence of more silicon; and it seems to me, as a result of several thousand such observations, that the harmful effects of sulphur have never been properly emphasized.

So far as I know, a lower sulphur content than 0.05% is seldom or never specified in foundry or other standard varieties of iron, and yet an iron with 0.050% sulphur is no more to be compared with a similar iron containing 0.025% sulphur than coke-made white iron is to be compared with cold-blast charcoal iron.

At the works above mentioned, as at many others, it is the custom to take from every cast a small chill cast sample (roughly 1.25 ins. by 2 ins. in cross-section by 7 ins. in length), remove it from the chill box when it has cooled to a dull red, quench it as quickly as possible and break it.

When the furnace is running on basic iron of standard composition, these chill samples will show from the faintest line of white at the lower corners, with 1% silicon and, say, 0.02% sulphur to dead white with lower silicon and higher sulphur. Through a very large part of the range of analysis covering the best basic irons low in both sulphur and silicon, these samples are solid white, and their variations in fracture, according to the sulphur present, are astonishingly great to be covered by the single title "white." It is not necessary to go into a detailed description of these variations here. I will only say that the low sulphur irons have a beautiful bright, very markedly crystalline structure (the crystals being long slim pyramids with their bases against the sides and bottom of the chilled surface and pointing toward the center), while the higher sulphur irons have a structure increasingly flat and non-crystalline; and while the general surface of the fracture with low sulphur irons is always approximately a plane perpendicular to the length of the sample, this is decreasingly so with higher sulphur, the fracture eventually becoming almost conchoidal. At what are considered very moderate sulphurs for foundry iron, beginning about from 0.03 to 0.06% with low silicon iron, the sample becomes cracked in cooling, and at 0.075% sulphur, will frequently fall into many pieces at the lightest tap when cold, though, it should be said, this latter condition is apparently more marked at some times than at others, even though the irons contain identical quantities of sulphur, silicon and other elements, ordinarily determined.

That sulphur, however, is the principal cause of these variations of physical properties is sufficiently proved by the fact that with experience it becomes perfectly possible to estimate the sulphur in the iron by the fracture of its chill samples, and, as a general thing, to come within 0.01% of the laboratory determination.

With iron approaching 1% silicon the effects of sulphur are to some extent masked, but not completely. Its effect in reducing the size of the grain, increasing the depth of chill and blackening the color of the gray part of the fracture is plainly apparent.

That sulphur has an effect in producing a chill (throwing the carbon into the combined form), precisely opposite to that of silicon, is shown very clearly by a study of the chill samples, but this is so generally understood that there is no need to elaborate it here; though it cannot be too plainly stated that silicon is not on that account a complete neutralizer of sulphur.

The exact internal effects of sulphur in steel have been clearly shown by Prof. Arnold* and Mr. J. E. Stead,* and there is little or no reason to doubt that the action is the same in cast-iron. It may be well to recall here that this action, briefly, is to form a very fusible iron sulphide which remains liquid long after the rest of the iron has solidified, and disseminates itself between the grains of the iron, thus severing or weakening their continuity. It is not to be expected that silicon, for which sulphur has little affinity, should neutralize such an influence, whatever its effect may be in opposing that of sulphur on carbon. This point is of much importance practically, for the reason that much foundry practice at the present time seems to be founded on the belief that silicon is a neutralizer of sulphur.

Since the quantity of sulphur in iron increases considerably at each melting, it is natural that scrap which has had at least one remelting will contain a higher percentage of sulphur, and therefore will have a more marked tendency to chill, than furnace iron; and as high silicon iron will undoubtedly soften white iron, it is perhaps natural to assume that the addition of the former is all that is necessary to soften scrap. Undoubtedly such an addition will counteract, wholly or in part, the chilling tendency; but it does not follow that this remedy will neutralize all the other effects of sulphur. When it is remembered, moreover, that the action of silicon in preventing the formation of combined carbon is certainly completed at, if not below, 2%, the wisdom of using mixtures which contain more silicon than this limit as they come from the cupola is open to question, especially as silicon is a hardener on its own account, and beyond this percentage a weakener also. Silicon, when present in greater quantities than 2%, is also a great dirt producer in castings. This matter of dirt production does not receive much attention in general; but I feel confident that many sand holes in castings are due to silica, produced by the combustion of silicon in the cupola, and remaining suspended in the metal until the latter comes to rest in the mold, and gives a chance for the silica to separate.

The cleanness of castings made from low silicon furnace metal, as compared with those from ordinary cupola iron, would surprise those who have not witnessed the difference.

Just how far silicon neutralizes the evil effects of sulphur is one of the most important questions of foundry practice to-day, and should without doubt be investigated by some one able and competent to do it; preferably under the auspices of some engineering society.

Not much can be done to remedy high sulphur in the iron after it has passed through the cupola. The addition of manganese in some form in the ladle is the only method which has been tried to any extent; and it has yielded good results in some cases, though its use is open to various objections of a practical kind, such as the high cost of ferromanganese, which is practically the only form of manganese available for the purpose; chilling of the iron in the ladle, if the ferromanganese is charged cold; or the cost of pre-heating it, if it is charged hot. Nevertheless, there are many cases in which it could be profitably used, care being taken not to add too great an excess, and thereby increase the percentage of manganese in the iron to a point where hardness would result.*

So far as I know, calcium carbide has never been used for this purpose; but it is well worthy of a trial. It compares favorably with ferromanganese in cost, while its combining power and its affinity for sulphur are much greater; moreover, it is an endothermic compound, and therefore its decomposition would impart heat to the metal. Moreover, calcium, being a powerful deoxidizing agent, would tend to remove any oxygen present in the form of iron oxide. The possibility of the presence of iron oxide in a highly carbonized metal like cast-iron is strongly denied by some; but I am more and more convinced that it is present in white iron.

Much can be done, however, to prevent the absorption of sulphur by the iron in the cupola. The first step is, of course, to use iron and coke low in sulphur, the next is to use an iron containing considerable manganese, say from 0.75 to 1.5%, since this quantity slags off the sulphur and prevents it from entering the iron. In the running of the cupola much can be done by slagging it freely, and there does not seem to be any reason why additions of lime should not be made in such quantity as to neutralize the extreme acidity of the slag. If from 1 to 2 lbs. of limestone were charged for every pound of silica in the coke ash, the slag would be very fusible as compared with blast furnace slags, but enormously more powerful in the removal of sulphur than one without lime. In a 10-ton heat with a melting ratio of 10 to 1 and coke containing 7% silica, there would be 140 lbs. of silica in the charge, and 200 lbs. of lime added to this would have a marked effect in reducing the sulphur-content of the resultant iron if at all excessive, at an utterly insignificant cost.† A still more calcareous slag would be inadvisable, under the present conditions of cupola practice, because, with the cold blast used, a sufficient temperature would not be attained to melt it. But this brings up the question: Why are not cupolas blown with warm blast?

A calculation of the quantities of heat required and expended in melting iron, or an examination of the top of a cupola in operation, will show that there is plenty of available heat, which could be utilized to save fuel. It has been calculated that from 25 to 40% in fuel consumption could be saved by heating the blast; and this would permit the use of relatively calcareous slags which would reduce the sulphur-content and give better iron—results opposite to those obtained in general practice, when any attempt to economize in fuel is made with cold blast.

The means of heating the blast could be very simple, merely some wrought or cast-iron pipes located in an enlargement of the cupola stack and connected by return bends, with external joints out of reach of the fire. The quantity of air admitted at the charging door would give a simple means of controlling the temperature and thus avoid any damage to the pipes. The blast would pass through the pipes in series on its way to the wind-box, and could probably be heated as hot as desired without difficulty and without excessive cost for repairs. The pipes would be exposed to no danger of being burnt up when there was no air passing through them, because at such times the cupola would not be going to any extent worthy of consideration.

*Various papers in "Journal of the Iron and Steel Institute."

*Since this was written, I have heard of a method, developed in Germany for removing sulphur by adding manganese-ore to the charge. This absorbs the sulphur and slags it off, very much as if the manganese were in the metallic state, but at less expense. I have no exact details of the process and its results; but it is said to have been successfully used in Germany.

†"The Effect of Limestone Additions on Cupola-Melted Iron," by F. Wüst. Stahl und Eisen, Jan. 1, 1904. Translation in American Machinist, May 12 and 19, 1904. This excellent article describes a very complete series of practical tests and their results.

SCREW SPIKES FOR RAILWAY TRACK.

In a recent report by Dr. Hermann von Schrenk, of the U. S. Department of Forestry, much interesting information is given as to the use of screw spikes for fastening rails to the ties. These spikes are in almost universal use in Europe for tracks laid with tee-rails, and various forms have been devised by the engineers of different railways. In this country there has been very little progress in this line, and the old (but erroneous) idea that a certain play should be left between the rails and ties still obtains to some extent. The report referred to includes mention of a screw spike or lag screw used on the Kansas Pacific Ry. in 1870, but does not include the screw spikes tried in more recent years by the New York Central Ry. and the Pennsylvania Ry. We quote the following as to the merits and early history of the screw spike in Europe, but space does not permit of following out the development of the various forms of screw spikes.

Of several devices advocated as a track fastening, the most promising is the screw spike. The chief advantage which the screw spike has over the ordinary spike is that, to a large extent, it is put in under circumstances which prevent the mechanical injury to the tie at the time, and when it is once put in it holds the rail to the tie so firmly that a large part of the wear is done away with. When in position a screw firmly clamps the base of the rail against the wood, and thereby causes the rail and the tie to act as one body when a load is passing over the rail. While it is not possible to absolutely prevent the sawing action of the rail even when held with a screw spike, nevertheless this action is reduced to a minimum by the use of other devices, such as tie-plates. A more secure attachment of the rail to the tie would not only prevent wear of the tie and of the wood around the spike, but would also increase the general stability of the track. The passage of the load over rails securely fastened to the tie would cause the whole body of the track to move in unison, and the up-and-down motion of the rails would be reduced to a minimum.

The first use of the screw spike in its simplest form was probably in Germany, where an extremely simple spike with a long spiral thread was used in the railways of the Grand Duchy of Baden before 1860. This is shown in Fig. 1, and was driven into the tie with a hammer. A similar form has recently been patented in this country. A lag screw used on the Kansas Pacific Ry. in 1870 is shown in Fig. 2.

The greatest progress in the use of the screw spike has without question been made by the French and Belgian railways. The French Northern and French Eastern and the Paris-Lyons-Mediterranean railways, as well as the Belgian roads, made tests with various forms of spikes as early as 1860. About 1878, at the eighth meeting of the German Railway Union, at Stuttgart, a report was made recommending the adoption of the screw spike instead of the ordinary spike. Figs. 3 4 and 5 show the forms of spikes used in 1880 by the French Eastern Ry., the French Northern Ry. and the Belgian State Rys. Fig. 6 shows the spike used by the Paris, Lyons & Mediterranean Ry. since 1889.

It is a reasonable conclusion that the proper device for fastening the flange of the rail upon the wooden ties is a steel screw spike, threaded hot, with a pitch of at least 0.472-in. for a shank with a diameter of 0.787-in. and with the length, diameter of core, and projection of thread calculated, respectively, to offer a resistance to a vertical pull (the nature of the ties being considered) about equal to the resistance to rupture under tension of the core of the screw spike. Finally, this screw spike must be driven into a hole previously bored with an auger having a diameter not appreciably greater than that of the core. This hole may be conveniently widened from 0.08 to 0.12 in. at the top to facilitate the entrance of the shank of the screw spike in the wood. The type of spike shown in Fig. 7 (that of the Eastern Ry. of France) practically fulfills these conditions, and it is the one now being tested in this country.

The Bureau of Forestry has lately tested the pulling strength of spikes at its timber-testing station at Purdue University. A special holder was constructed, contrived to grip the heads of the spikes in a manner like the action of the rail, and to pull them from the tie in the direction of their length. The load at which the spikes pulled out from the ties was measured in pounds. Common spikes were driven into actual ties by an experienced track foreman to a depth of 5 inches, and then pulled out by a testing machine. The machined screw spikes were screwed into the same ties by hand, after a hole

had been bored in the wood of a diameter equal to the diameter of the screw spike at the root of the thread (5/16-in.). The results were as follows:

Kind of wood.	Force required to pull spike. Screw spike. Pounds.	Common spike. Pounds.	Ratio of resistance of screw spike to common spike.
Chestnut	9,418	2,980	3.10
Oak	11,240	4,342	2.50
Long-leaf pine....	10,558	2,296	4.63
White oak	13,026	6,950	1.87
Loblolly pine	8,504	3,474	2.45

On some railways the ties are bored for spikes before being treated by a preservative process, and the spikes are dipped in tar oil before being driven. In some cases the spikes are screwed in by machine, as described in an article in our issue of June 23, 1904, but ordinarily they are screwed in by hand, with the aid of a cross-handled socket wrench. Prof. A. L. Smith, of the Worcester Polytechnic Institute, Worcester, Mass., has devised a machine operated by hand, and this is shown in Fig. 8. It consists of a tripod frame, having two legs clamped to the rail while the third rests upon the tie. This is adjustable as to height, in order to fit rails of any size. The machine having been placed in position on the rail, the lever (A) is depressed, thereby rotating the gear (B) and raising the column or sleeve (C) by means of the rack cut on the surface. This sleeve can slide in the head (D), but is prevented from rotation by a key. The shaft (E) can rotate in the sleeve, but can not move endwise therein. When (C) is raised, (E) is therefore raised with it. On the end of the shaft is a socket, which fits the shank of the drill or the head of the screw spike.

The screw spike having been placed in position in the socket, the lever (A) is raised enough to bring the point of the screw in contact with the tie. By turning the crank (F), the bevel gears and shaft E are rotated. As the shaft rotates, the screw is fed downward by weight of the parts attached to it, assisted by an upward pull on the lever (A). The workman grasps the handle (G), thus steadying the machine and himself as he turns the crank with the other hand.

After the screw spikes are once put in little work is required to keep them in proper condition. The wood is compressed by the threads as the screw enters, and the pressure of the core upon this highly compressed wood opposes a resistance to the loosening of the spike. However, after the spikes have been in position for a few weeks they have to be tightened. This is not because the screws have loosened, but because the ties, tie-plates, and rails have settled so as to come closer together because of the pressure of moving trains. After the screws have been tightened they remain so for long periods of time. Once a year the section crew goes over the track with great care, testing and tightening each screw, and, if any of the screws no longer hold, they are taken out. The hole is then filled with a plug, a new hole is made in the plug, into which tar oil is poured, and the screw is replaced. The wearing out of threads of the screw does not occur very often.

It is impossible at this time to give any exact and trustworthy information as to the relative cost of maintenance of tracks equipped with ordinary spikes and with screw spikes. In view of the fact that the screws do not work out of holes, as do the spikes, which means a less frequent replacing not only of fastenings, but of ties, it would appear that the cost of maintenance would be very much lower for the screw than for the spikes, and the condition of the track generally better. The first cost of putting the screws into position is somewhat higher than that for placing spikes. This is principally due to the longer time which the operation takes.

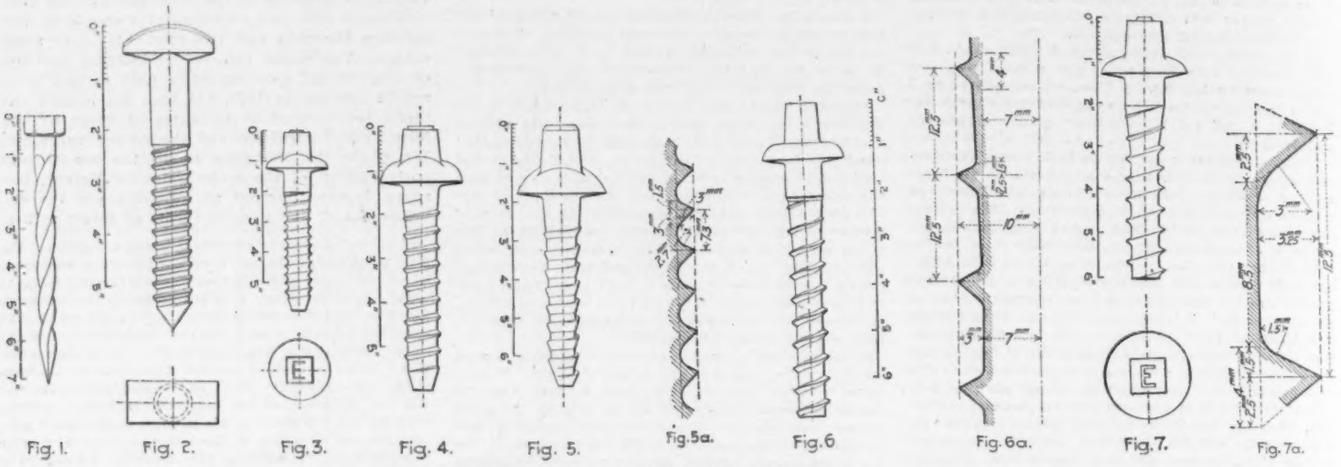


Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5. Fig. 5a. Fig. 6 Fig. 6a. Fig. 7. Fig. 7a.

FIGS. 1 TO 7. FORMS OF SCREW SPIKES.

ANNUAL MEETING OF THE LAKE SUPERIOR MINING INSTITUTE.

The tenth annual meeting was held in Ironwood, Mich., and Milwaukee, Wis., on Aug. 16, 17 and 18; the trip was made in a special train of sleeping cars, and the party comprised about 200 members and guests. Visits were paid to a number of mines on the Gogebic range, while at Milwaukee there were trips to a number of manufacturing plants having mining machinery as their specialties. Two business meetings were held, one at each place, but only a few of the papers on the program were read. The secretary's report showed a membership of 432, with 371 active members. The following officers were elected: President, O. C. Davidson, Iron Mountain, Mich.; Vice-Presidents, W. M. Duncan and F. M. Prescott; Treasurer, E. W. Hopkins; Secretary, A. J. Yungbluth, Ishpeming, Mich.

Among the papers presented was one by Mr. James R. Thompson, on the subject of mine hoisting engines:

THE HOISTING PROBLEM.

A simple Corliss engine gives more economical results used for the driving of hoisting apparatus than any compound or triple expansion engines. The test of time in the Superior region seems to show that the ideal requirements are for an engine of the Corliss type with 150 lbs. pressure, hoisting a load from the bottom of the shaft in one minute, and making the round trip, up and down, in three minutes, or about 20 trips an hour. The most feasible balance should be used, and the engines should be of as high a rotative speed as possible, as greater economy of power is obtained thereby. With engines of this type straight drums should be used of as small a diameter as possible. In connection with the installing of equipment, many Superior region mines are making the mistake of attempting to discount the future by building plants that will be too large for many years. The result is that interest in the long run amounts to more than the building of a new plant.

We shall publish later an abstract of a paper by Mr. H. B. Sturtevant on the sinking of two shafts through quicksand. At the Milwaukee meeting, Mr. V. S. Hillyer presented a paper on the practical use of magnetic attractions for exploration purposes, and some notes of this are given below:

MAGNETIC SURVEYS.

We have no well established method of procedure, and the instruments used and principles involved are not generally understood. However, the instruments are simple in construction and easily manipulated. They are the miners' dip needle and the dial compass. The dip needle is a magnetized, or a compass needle so pivoted as to swing in a vertical plane, and when not affected by local attractions, the needle stands approximately horizontal. The dial compass is a more valuable instrument, for in addition to taking magnetic observations with it an accurate closed survey may be made regardless of local attractions. The dip needle is principally used now as a check, and also to emphasize the results obtained by the dial compass.

The dial compass consists of a well-made compass surmounted by an hour circle and gnomon, making a sundial in which the gnomon is in the vertical plane of the north-south axis of the compass. When the instrument is level and the north-south axis is in the astronomical meridian, the shadow of the gnomon indicates sun time on the hour circle. Conversely, if the instrument is level and so held that the shadow falls on sun time, the north-south axis must lie in the astronomical meridian. The declination east or west of the compass needle from this meridian gives what is called the magnetic variation, or simply variation.

In construction the angle of the gnomon and the divisions of the hour circle must correspond to the latitude of the area under examination. Practically it is found that, in this region, the angle the gnomon makes with the hour circle may vary from the latitude of the place of observation one half degree without appreciable error. In lower latitudes the permissible difference would be more, and in higher latitudes less.

The two principal minerals causing magnetic attractions are magnetite and pyrrhotite, the latter being less magnetic. In the Sudbury district pyrrhotite is important because of its associated ores of nickel and copper. Magnetite occurs in grains and small masses, more or less abundantly disseminated through various rock formations. It often occurs in such large masses as to be valuable iron ore deposits. In disseminated grains it occurs

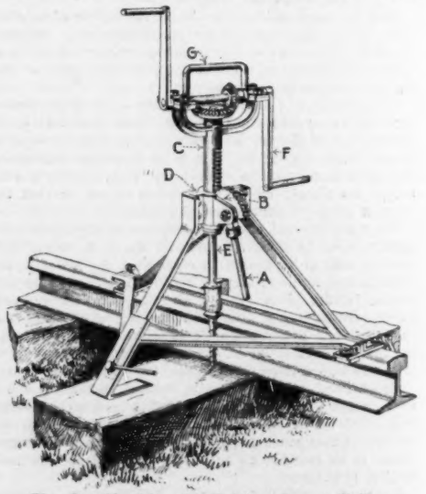


Fig. 8. Machine for Driving Screw Spikes.

along the contact of intrusive rocks and also along some beds of sedimentary formations. The effect on the magnetic needle of any of these occurrences is strong or weak depending on the amount of magnetite and its distance from the instrument.

The forces acting on the compass needles are magnetic attractions from the north pole and from local poles, the force of gravity, and the friction of the needle pivot bearings. The position assumed by a magnetic needle is due to the resultant of all these forces. It frequently hap-

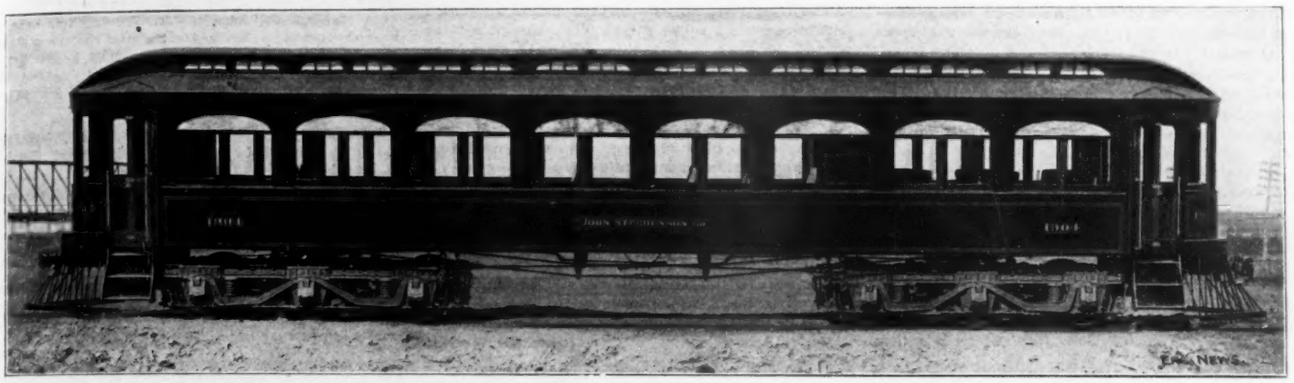
ions, however, that the force due to a local magnetic pole is so strong in comparison to all other forces, that their effect is negligible, and the needle will point directly toward or at the local pole.

In the Swedish methods, the instruments are mounted on tripods, and are more delicate in construction than those of this country, and require as much care in their manipulation as an engineer's transit. By means of an auxiliary magnet, placed on and off the instrument during an observation, the effect of the normal terrestrial magnetic force is eliminated, and only the forces due to local magnetic poles are measured. This constitutes the essential difference between their instruments and ours. Their measurements are expressed in absolute units, which may be figured from the instrument readings, but which in practice are taken from prepared tables. They also record the magnetic variation. From a practical point of view it may be asked if a magnetic survey is worth its cost. To this may be answered unhesitatingly, "Yes, but only when done understandingly." Which method and to what extent it should be applied depends entirely on conditions.

A magnetic survey is generally made in connection with a geological survey, in which case the running of successive parallel traverses is the most thorough and quickest method of procedure. It often happens that the magnetic observations are the main object, when a different procedure will be found preferable. By closely following the magnetic line and at intervals running a traverse to it at right angles, much time will be saved. As a rule, in this work a pacing survey will be sufficiently accurate for all practical purposes, and it is seldom worth while to take magnetic observations closer than 25 paces.

To trace a magnetic line the dial compass is used, and the method is to zigzag across the magnetic line or maximum attraction by means of short courses at right angles. The crossing of the magnetic line on any course is indicated by a change in direction, east or west, of the variation, or else by a maximum variation, as explained above. The change in direction of the variation is of course east or west of the normal magnetic meridian.

The Swedish methods are slow and expensive as compared with the American methods. The Swedish instruments could be used with American methods, and more delicate and accurate magnetic measurements obtained. But where the controlling influences are so obscure, and the reliability of the final deductions depends on the judgment of the operator, the refinements of these instruments do not seem warranted by practical considerations. For purposes of exploration, the dial compass and dip needle and a pacing survey, with a competent operator, will give all the results necessary for practical purposes.



ELECTRIC CAR FOR HIGH-SPEED SERVICE; SIX-WHEEL TRUCKS AND FOUR 200-HP. MOTORS.
John Stephenson Co., Elizabeth, N. J., Builders.

ELECTRIC CAR WITH SIX-WHEEL TRUCKS AND MOTORS OF 800 HP.

In the development of electric cars for high-speed service on interurban railways, the maximum power equipment so far used consists of four motors of 125 HP., and this arrangement is found to be so extravagant in the use of current that an equipment of four motors of 75 to 100 HP. is being regarded as the maximum for economical service, unless for exceptional circumstances. In exceptionally high speeds, and this car is designed to be equipped with four motors of 200 HP. each. This car was designed and built by the John Stephenson Co., of Elizabeth, N. J., and represents an interesting departure from ordinary practice. A view of the car is given herewith.

The car is 46 ft. long over the body and 57 ft. over the bumpers; it is 8 ft. 9 ins. wide over the sheathing and 9 ft. 8 ins. high from bottom of sill to top of roof. The total weight is 39 tons. The underframe consists of six longitudinal sills; the side sills are each composed of two pine timbers, with a steel plate sandwiched between them; the other sills are 6-in. I-beams, with wood fillers. The cross bars are of malleable iron, each with two truss rods, and they are so arranged that electric or air brake apparatus can be suspended from them. On top of these bars is laid "transite" board ¼ in. thick, and on this again is the floor, securely fastened to the side sills and center sill fillers. These fillers are covered with "transite" board, and the construction is such as to be practically fireproof and sound-proof. The frame is equipped with built-in bolsters, having heavy steel center plates and 3-in. king pins; all parts are machine fitted. The total weight of the underframe is 20,000 lbs. The body is divided into three compartments: passenger, smoking and private, with a total seating capacity of 52 passengers. The ends are vestibuled, and are tapered to reduce the air resistance.

The use of six-wheel trucks was decided upon as being necessary for easy riding at very high speeds. These trucks are built heavier than the ordinary six-wheel trucks of steam railway cars, on account of the motors they will carry. The side frames are made of I-beams, with solid steel fillers, all of these fillers being milled and machine fitted. The wheels are 36 ins. diameter, steel tired, with M. C. B. standard treads and flanges. On the center wheel the flange has been omitted in order to enable the trucks to take 60-ft. curves. The axles are 6½ ins. diameter, with journals 5½x9 ins. The oil boxes are of malleable iron, and all other castings on these trucks are either of malleable iron or steel, the only gray iron castings being the brake shoes. The wheel base of driving axles is 10 ft. 4 ins. The truck bolster is of special construction and built exceptionally rigid to withstand the heavy work required of it. In designing this truck many new features had to be introduced in order to accommodate the motors and at the same time maintain the riding qualities peculiar to the six-wheel truck. The weight of these trucks is 19,000 lbs.

A PROBLEM IN LOCATING TURNOUTS.

By C. M. Kurtz.*

Existing field books give methods for connecting a curve and a tangent to another curve, but these rarely prove practicable in ordinary work in laying out tracks, on account of the entire disregard of the fact that one must use a frog of a certain angle of which the roadmaster has a supply for such work. In applying the problems as found in the field books where a turnout is to form a connection with an established tangent, the engineer is restricted to the use of but one curve, the degree of which is that of the theoretical curve of the turnout, which equals the degree of curve of turnout from a straight track plus or minus the degree of the curve of the track from which the turnout springs. The use of this one curve will rarely prove desirable on account of its being either too sharp or too flat.

As shown in the accompanying figures, four general cases of the problem present themselves. The necessary field work in each case consists in measuring the angle between the center line of the tangent and the tangent to the center line of the curve at the point of intersection; or better yet, the angle between a line offset one-half the gage, and the rail which will pass through the frog, as the latter will simplify the problem, and the radius of the rail is determined simultaneously by measuring the middle ordinates for one or more chords.

Having the angle of intersection as described above, the radius of the curved track, the angle of the frog to be used and having selected a radius for the connecting curve, the essentials of the location are—the distances between the point of

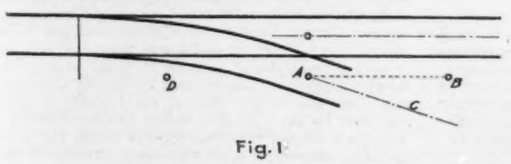


Fig. 1.

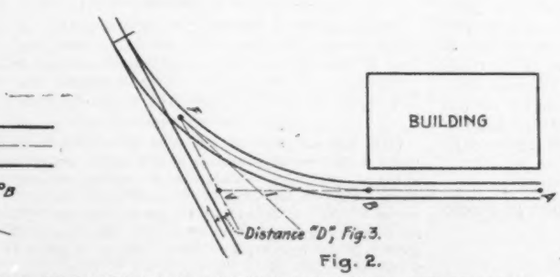


Fig. 2.

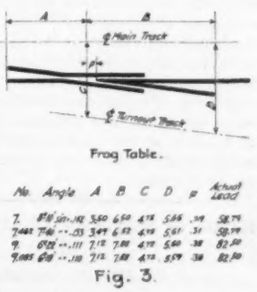


Fig. 3.

FIGS. 1, 2, 3. METHODS FOR LOCATING TURNOUTS AND FROGS.

*Chief Draftsman, Engineering Department, Assistant Engineer's Office, So. Pac. Co., Ogden, Utah.

intersection and the point of frog, the central angle of the connecting curve and the distance between the point of intersection and the B. C. of connecting curve.

The following solutions offer ready and accurate methods of obtaining the above-named points:

In the figures, let C A represent a line offset one-half the gage from the center line tangent, which is to be connected with the gage line of the rail of the curved track by means of a frog having an angle = F and a curve whose radius = R'. O and O' are the centers, I the point of intersection where the angle α has been measured and the other notation as shown in the figures. The rail opposite the frog, and the switch rails are not shown as they have no bearing upon the problem.

Determine the angle I O F; then measured on the curve,

$$I F = R \times \text{angle I O F in minutes} \times \text{a constant}$$
$$(= 0.00029089), \text{ or Chord I F} = 2R \times \sin \tfrac{1}{2} \text{I O F}.$$

$$\text{In the triangle O O' B, Cos O' O B} = \frac{OB}{OO'}$$

O O' is determined by solving the triangle O F O' of which the angle F and its including sides R and R' are known. This also determines the angles F O' O and F O O'.

Cases 1 and 3. $OB = BC + OC = R' + R\cos\alpha$

Cases 2a and 4a. $OB = BC - OC = R' - R\cos\alpha$

Cases 2b and 4b. $OB = OC - BC = R\cos\alpha - R'$

It should then be noted that when O B is computed to be greater than O O', impossible conditions have been imposed; the radius of the connecting curve has been taken too large.

Having determined the angle O' O B, from the figures:

Cases 1 and 2a. $I O F = \alpha - (F O O' + O' O B)$

Cases 3 and 4a. $I O F = 180° - (\alpha + F O O' + O' O B)$

Case 4b. $I O F = O' O B - (O' O F + \alpha)$

Case 2b. $I O F = \alpha - (180° - O' O B + F O O')$

Cases 1 and 2a. $A O' F = O' O B - F O' O$

Cases 3 and 4a. $A O' F = F O' O - O' O B$

Case 4b. $A O' F = F O' O - (180° - O' O B)$

Case 2b. $A O' F = 180° - (O' O B + F O' O)$

To determine the distance A I:

Cases 1 and 2. $A I = A C - I C = O' B - I C = O' O \sin O' O B - R \sin \alpha$

Cases 3 and 4. $A I = I C - A C = R \sin \alpha - O' O \sin O' O B$

The engineer should be careful to add or subtract one-half the gage to the center line radii, as the case may require.

The point A which is the B. C. of the connecting curve, and the point F which is the theoretical point of frog and E. C. of the connecting curve can now be readily fixed in the field and the entire connection staked out.

While the writer realizes that it is better practice to pass the frog end of the connecting curve at the heel of the frog, to impose that condition in the above problem would complicate it beyond measure. In inserting 10 or 15-ft. frogs in a curved track, the trackman cannot help slightly changing the original alinement of the track at that point, and energy spent in making a closer solution than that outlined above will surely be wasted.

A METHOD OF MEASURING DEFLECTIONS IN FLOOR TESTS.

By Edward Godfrey.*

The following description of the method employed to measure the deflection of a floor under test may be of interest to any who have similar tests to make.

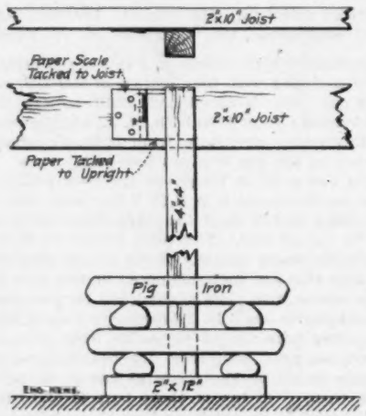
The floor tested was in 20-ft. squares, and it was desired to obtain the deflection at the middle of the square tested, as well as at the middle of the side of the square, or half way between the columns. To accomplish this, pedestals or uprights were made of a single 4 × 4-in. piece of wood nailed to a block about 2 × 12 ins. by 2½ or 3 ft. long. These were placed on the floor at points where the deflections were to be measured, and blocks of pig iron were placed upon them to weight them down, so as to prevent displacement by the men in loading the floor. Enough pig iron was placed on each pedestal to make up approximately the required load for the space which it occupied.

In addition to the pedestal there had been placed 2 × 10-in. timbers which reached across the floor space and were nailed to posts resting on the floor near the columns. These were about at the level of a man's head, so as not to be in the way of the men who were loading the floor.

They were vertically over the points at which deflections were to be taken. The uprights were placed so that a flat side of the 4 × 4 was against the joist or timber which reached across the floor. On the back of the upright there was tacked a sheet of stiff paper, upon which was ruled a horizontal line. On the joist was tacked another sheet of stiff paper, the edge of which had been divided accurately into tenths of an inch. This was set with the zero of the scale at the horizontal line on the sheet tacked to the upright.

As the floor deflected, the amounts of the deflections could be instantly read on the scale to hundredths of an inch, by estimating tenths of scale divisions. The apparatus is more clearly shown in the accompanying sketch.

A number of scales were ruled at the same time by tacking the sheets down on a drawing board with about ½-in. along the edge of each exposed. By dividing one sheet with a decimal scale and ruling across the exposed edges all were made alike. The tenths could be further divided into five parts or fiftieths with a hard pencil, but no difficulty was experienced in estimating the hundredths with a scale divided into tenths.



Apparatus for Measuring Deflections of Floor Panels in Load Tests.

*Monongahela Bank Bldg., Pittsburg, Pa.

THE 21,000-TON STEAMSHIP "MINNESOTA," of the Great Northern Steamship Co., arrived in New York on Aug. 22 from the yards of her builders, the Eastern Shipbuilding Co., of New London, Conn. A detailed description of this vessel will be published in our next issue.

THE GRAND TRUNK PACIFIC RY. is to be built under a government guarantee of 75% of the cost of construction. This is a change from the original agreement, under which the liabilities of the government were not to exceed $13,000 per mile in the prairie sections and $30,000 per mile in the mountain sections. The time for the completion of the line has also been changed to December, 1911.

A CHICAGO RIVER TUNNEL at Dearborn St. is now proposed by Mr. John Ericson, the City Engineer, as a substitute for the old La Salle St. tunnel, two blocks west. The old river tunnels are to be lowered in order to give a greater depth of water in the river, but it has been found that the lowering of the La Salle St. tunnel would endanger a water supply tunnel which lies almost directly beneath it.

LARGE COAL PIERS with coal-handling machinery are being built at Milwaukee, Wis., some of these being entirely new, while others are extensions of existing piers. One of the largest is 700 ft. long and 400 ft. wide, being adapted for the storage as well as the handling of coal. In connection with these piers improvements will be made to the inner harbor to enable large coal steamers to reach the piers without difficulty. The improvements include dredging and widening the rivers and building new [illegible] bridges of the bascule type to give wider channel [illegible] ings than the swing bridges.

THE SEWAGE DISPOSAL WORKS OF SHEFFIELD, England, are to be greatly altered and extended, in case the Local Government Board approves the plans for that end recently submitted to it. It is proposed to remodel and extend the present chemical precipitation tanks, substituting plain sedimentation, as we understand it, for chemical precipitation, and build 60 contact beds, each one-half acre in size. Special filter beds will also be constructed for the treatment of the storm flow of sewage. The plans have been prepared by Mr. C. [illegible] Wike, M. Inst. C. E., City Surveyor of Sheffield. The city, it may be added, has a population of about 425,000.

A STRANGE IRREGULARITY IN THE FLOW OF A spring has been reported to us by Mr. David Hinckley, of Lindale, Floyd Co., Ga., as follows:

Braham spring is near Huntsville, Ala., and the water flowing from it is used by the Merrimack Manufacturing Co. for a domestic water supply and also for the condensers for two 1,200 and 2,500 HP. engines. The flow of the spring varies from some 4,000,000 to 6,000,000 gallons per 24 hours. On the evening of Aug. 4 there was a very heavy thunderstorm. On Aug 5, about noon, it was noticed that the water in the pump-well had been drawn down lower than usual, and an investigation at the spring showed that the flow of the spring had almost entirely stopped, and that the small storage basin at the intake end of the conduit leading to the pump-well was practically empty. By night time it was entirely so, and it was feared that the backing up of the spring about 3 ft. above its original level, due to building a small dam just below the intake last Fall, had caused the spring to find a new outlet, but by daylight of Aug. 6 the spring was flowing as usual, except that the water, usually perfectly clear, was very muddy. The muddy condition of the water disappeared in a couple of days, and since then the flow of the spring has been normal.

A NOVELTY IN OIL-SEPARATORS is an electrical separator described in the "Electrician," of London, in its issue of May 27, 1904. The separator is designed to remove the oil from the air-pump discharge, before this is fed to the boiler. The separator is very similar to a storage-battery in general arrangement. Electrode plates are suspended in wooden tanks, through which the air-pump discharge flows in a continuous stream. A little ordinary water is fed in with this stream, so as to reduce its very high ohmic resistance. The electrode plates are of sheet-iron; each tank contains ten plates, alternately negative and positive. The water flows alternately under and over these plates, so as to have maximum exposure to the electric current. The plates of similar polarity in each tank are connected in parallel, and several tanks are joined in series. A plant at the generating station of the Leicester (England) Corporation Tramways consists of ten in series, and is said to require 12 amperes at 500 volts (?), and takes care of 6,000 gallons per hour. This represents the usual energy consumption claimed by the manufacturers, 1 KW.-hr. per 1,000 gallons. The action of the electric current is "to cause the emulsified oil to coalesce, and when the liquid is subsequently passed through a mechanical filter there is no difficulty whatever in catching the particles of oil, thus allowing the remaining water, which is exceptionally pure, to pass to the hot-well." The plates are said to become coated with a deposit after some time, but this is easily removed by reversing the current, whereby the deposit rises to the surface and may be skimmed off. This separator is known as the Davis-Perrett, and is made by the Davis-Perrett Company.

COPPER SULPHATE AS AN ALGAECIDE is being subjected to a careful study at Springfield, Mass. First of all the Belchertown reservoir was treated, and now some experimental tanks have been erected on the bank of the Ludlow reservoir. It appears that the Massachusetts State Board of Health has been unwilling that copper sulphate should be tried on water used for domestic purposes until more could be learned about what finally becomes of the chemical when applied to water, and what its effect is upon animal life. Accordingly, a reservoir at Belchertown was selected which was not at the time connected with the water-works distribution system. A representative of the board named, Dr. Kellermann, of the U. S. Department of Agriculture, and Mr. E. E. Lochridge, Engineer of the water department of Springfield, were each present at the trial. Copper sulphate in about 1 part per 8,000,000 was applied to the water. The anataena disappeared rapidly, but the State Board of Health reports that laboratory samples of water taken 24 hours after the introduction of the chemical showed practically all the sulphate of copper which had been applied. The water is described as "extremely soft." The reservoir has a capacity of 56,000,000 gallons. Before making its final report on the subject, the State Board of Health requested that further studies be made. To that end four 600-gallon tanks have been erected at the Ludlow reservoir, long notorious for being infested with algae at times. These tanks will be used to study the disappearance of copper sulphate, succeeding some 5-gallon carboys used at the reservoir for that purpose.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Entered at the New York Post-Office as Second-Class Matter. Published every Thursday at St. Paul Building, 220 Broadway, New York, by

THE ENGINEERING NEWS PUBLISHING CO.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE, 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50: 10 weeks, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $8.00; Thin Paper Edition, One Year, $6.75. SINGLE COPIES of any number in current Volume, 15 cents.

In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 325 means that subscription is paid to the 32d week (that is the issue of Aug. 10) of the year 1905; the change of these figures is the only receipt, unless one is sent by special request.

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Numerous as are works for the treatment of sewage in England, most of the seaside towns depend upon disposal by dilution in salt water. This appears to give quite general satisfaction wherever there is no serious danger of contamination of shellfish. Where for some local reason treatment is required, it often happens that straining or a few hours of sedimentation is sufficient. If a further removal of suspended matters is required a choice may be made between chemical precipitation and septic tanks. Elsewhere in this issue will be found an abstract of a paper on "Seaside Sewage Disposal," recently presented before the Royal Institute of Public Health at Folkestone, England, by Mr. Arthur J. Martin, Assoc. M. Inst. C. E. Although Mr. Martin's connection with the septic tank naturally inclines him to that process of treatment yet little allowance needs to be made for that fact by readers of his paper. Unquestionably the septic tank is in some respects peculiarly adapted for use at seaside towns. One of its greatest advantages for such localities is that it can be operated without any loss of head, an important feature in the case of flat-lying towns, and another is that it minimizes the sludge disposal problem. On the other hand, septic sludge is sometimes decidedly offensive, a fact which might well be borne in mind in selecting a site for such tanks and particularly in choosing a time for removing sludge from them.

The caution displayed by the Massachusetts State Board of Health in regard to the use of copper sulphate as an algaecide may strike some people as unnecessary, but coupled as it is with an investigation bearing upon the probable effect of the chemical upon animal life it deserves hearty commendation. It is true that such infinitesimal amounts as 1 part per 1,000,000 and sometimes as low as 1 part per 8,000,000 of copper sulphate would not seem capable of injuring any human being, even if all of it remained in its original form. It has been claimed that all traces of the chemical disappear, in at least a majority of the cases where it has been used. The truth of this claim, and in case it is untrue the final disposition of the copper sulphate, is now being investigated by the board and its conclusions will be awaited with interest. Water-works men will also anxiously await the conclusions of the board regarding the efficiency of the algaecide under varying conditions as to character of water and species of objectionable organic life. We say all these things without meaning to question in any way the assurances of Messrs. Moore and Kellerman, of the U. S. Department of Agriculture, but because corroborative evidence is always valuable and because the Massachusetts State Board of Health has so long been regarded as an authority in matters relating to the quality of public water supplies.

A most interesting announcement is made on another page of this issue—the news that a single-phase alternating-current railway has been put into commercial operation at Schenectady, N. Y., the first in the United States. Only a few weeks ago a single-phase line in Germany started regular service, but no reports of its operation have yet been received. Two years ago the Westinghouse Electric & Mfg. Co., of Pittsburg, Pa., set about equipping a single-phase railway line in Maryland to connect Washington, Baltimore and Annapolis. Had this work been put through on schedule time it would have been the first regularly-operating single-phase line in the world. But, unfortunately, that railway enterprise encountered financial difficulties and the contracting company stopped work on the equipment. Also about two years ago, Mr. B. J. Arnold, of Chicago, Ill., began to build a line in Michigan which he planned to equip with an ingenious system of single-phase induction motors combined with auxiliary equalizing air engines. The motors were to be operated from a single-phase trolley wire. But in January of the present year, 1904, when he was just about to give an exhibition run on this line, preparatory to starting regular service, the car barn of the line burned down, and with it most of the equipment which had been built.* So it happens that the distinction of building the first commercially-operating single-phase railway in this country goes to the General Electric Co.

Stress is laid on "commercially-operating" because that is the feature which to the lay mind embodies the successful realization of any system or device. Experimental runs and exhibition trials are accepted only at a nominal value; they still leave open the question, "How will it work in actual practice?" And there is a real basis for this popular attitude. The many complex and often unforeseen demands upon reliability, economy, emergency qualities, etc., which are imposed by operation in every-day commercial working constitute the real test of a device. Thus, though the single-phase railway motor, long an ideal and an object of study to electrical engineers, has been a practical reality for a year or more past (at least in the shops of electric manufacturers), yet its actual existence must be dated from its first commercial use.

It merits notice that the type of single-phase motor which has won its way into railway service is a commutator motor, a machine in which the commutator is not an auxiliary device but one of the main essentials. This applies to the motor used on the German line referred to, to the motor planned to be used on the Washington line, and to the motor used on the Ballston line. It also applies to a motor which was operated on trial runs in Milan, Italy, a year ago (which, indeed, is of the same type as the Westinghouse and the General Electric machines), and to the repulsion motor, which has been the subject of much experimentation for some years by the General Electric Company with a fair degree of success. In all these machines the commutator is as vital as in the direct-current motor. Thus the early ideal of the alternating-current men, a motor without commutator but yet having universal applicability, is abandoned. It may be that the tenacious adherence to this ideal had something to do with retarding the development of the series alternating-current motor; this, if true, is unfortunate, for the series motor proves itself to be an excellent machine, perhaps as valuable as the direct-current series motor has been. Yet there was, and still is, ample justification for the adherence to that ideal. If the commutator could be avoided, not only would the wear and tear and worry of that troublesome device be done away with, but it would be possible to work the motors at high voltages. Then the motors could be made smaller and lighter, and the added weight of a potential transformer on the car would not be necessary, except as it might be desired for control.

The single-phase induction motor, similar to the polyphase motors which have found wide use for general power purposes, was long the subject of attempts to reach this ideal. But it could never be brought to the point where it would start alone, at least under load; by special means it has been made self-starting for such purposes as driving fans, where the start is made under no appreciable load. If it can be successfully utilized by some auxiliary device for balancing and starting, such as is used by Mr. Arnold in his electro-pneumatic system, it may yet become a competitor of the commutator motor. But if this plan fails, then we may expect that "single-phase railway motor" will always mean a commutator motor.

Among the several types of single-phase motor employing a commutator, the series motor appears to have the lead. In addition to its use in Europe and in the Westinghouse single-phase railway system, it has now been put into actual use by the General Electric Co. after a great amount of experimental work on both the series and the repulsion types. The professed reason for the choice of the series motor over the repulsion machine is that the former can work on direct as well as on alternating current, and hence can run on mixed lines. Why this feature is an advantage is more fully considered in the descriptive article on another page. Undoubtedly the advantage is a great one, especially in the present condition of electric traction, with direct-current standardized and vast amounts of investment based on it. Yet it would be interesting to know how the series and repulsion motors compare in actual working results when this advantage is neglected. If in this comparison the repulsion motor can show superior results, its day may yet come.

Some attention is due to the increasing amount of apparatus and complexity which comes with every advance in electric traction matters. The Arnold electro-pneumatic locomotive gave a foretaste of what we may have to deal with in the future. So also does the new General-Electric single-phase car show a very notable increase in bulk and weight of equipment over the ordinary direct current car. The underside of the platform is well filled with the machinery hung to it. A little of this might be saved if the car were run on alternating-current alone, and somewhat more if no air-brakes were used. But the probabilities are for an increase rather than a decrease in the future. The Westinghouse single-phase car equipment, according to authoritative information,* weighs from 10 to 20% more than the equivalent direct-current equipment, and presumably its bulk is greater in proportion. Now in neither the General Electric nor the Westinghouse car has the multiple-unit control been included. The apparatus necessary for this adds a respectable item to the sum-total of car-equipment.

To accommodate the increasing amounts of machinery under the floor, cars must be made ever longer. And in that case the heavy loads suspended from the floor may deserve some attention, especially since we know from steam-railway passenger-car experience that the problem of building cars strong enough for all requirements is not a simple one. Perhaps all this may lead toward the use of electric locomotives, or at least to a construction involving a machinery-space in the body of the car.

The type of overhead construction for the alternating current used on the Ballston line represents a noteworthy new design in a matter whose importance to the future of electric railway development is second only to that of the motor itself. The supply of current

*See an article on "The Arnold Electro-pneumatic Railway System; Its Application to the Lansing, St. Johns & St. Louis Ry.," by B. J. Arnold, in Engineering News of Jan. 7, 1904, p. 17. See also p. 15 of that issue.

*See "Interurban Electric Traction Systems; Alternating Current versus Direct Current," by P. M. Lincoln, Engineering News, Dec. 17, 1903.

to a train traveling at high speed and drawing a large amount of power, the *safe* supply of this current and the maintenance and durability of the supply system are by no means simple or completely-solved problems. The work done on these problems in the past few years is evidence of their importance. The bow-trolley competes with the wheel-trolley; the lateral trolley-wire makes its claims against the central wire; the old rigid suspension from bracket-arms has been found wanting and points toward flexible suspension. The flexible support of the trolley-wire by an auxiliary transverse span-wire, as developed in American interurban practice or as used in another form on the Berlin-Zossen experimental line, and the catenary suspension from a longitudinal cable, as tried in Europe or in a simpler form on the Ballston line, all speak for the need of an overhead construction more suited to the exacting mechanical requirements of the case than the type in use to-day. With the alternating-current motor higher voltages must be taken care of in the trolley wire; hence, insulation, etc., must be given more thought. Also, if main-line railways are to make successful use of electric traction the dangers of the current to train crew and passengers must receive consideration. Again, as the General Electric Company has pointed out, with mixed steam and electric operation on a single line, it is important to get the overhead work out of the way of smoke and gases from the locomotive stacks. These, together with the omnipresent consideration of cost, are some of the questions bearing on the matter of overhead construction. The particular solution adopted on the Ballston line seems to answer many of them: the overhead work is flexible, it facilitates insulation by giving an insulator support from below, it is out of the way of brakemen and of smoke from locomotive stacks, and it is low enough to pass culverts and tunnels easily in most cases. Whether the design was called forth by the special conditions of that line, where the alternating-current work had to be put in on existing direct-current overhead work without interfering with the latter, or whether it was elaborated on a more general basis, does not affect its merits.

THE CAUSES OF UNDERESTIMATES OF COST OF PUBLIC WORKS.

A young engineer when called upon to estimate the probable cost of work to be done by contract usually finds little to guide him in the text-books that he has used at college; and, having no records of his own, is more than likely to use the lists of contract prices given in recent files of engineering journals. This act marks the beginning of a habit that is apt to grow until it becomes the standard way of making estimates of cost. If the engineer is engaged in railway work, the bidding prices of which are seldom made public, he pursues a slightly different method, although one that is essentially the same. Either from other engineers, or from contractors, he secures some records of bidding prices, and these form the nucleus of a record book from which he is enabled to "get a line on" probable bidding prices for any given class of work.

There are unquestionably many engineers who do not follow some such procedure as this in estimating costs, but we fear that they are not in the majority. An excellent illustration of how far this practice is carried among city engineers is had in the following statement of fact: A score or more of letters of inquiry were sent out to city engineers, known to have been in charge of a certain class of municipal work, asking the approximate actual cost of one item. One of the first replies received was characteristic of practically all; it was in substance as follows:

> All our city work is done by contract, so that I am sorry not to be able to reply to your question as to the actual cost of such work to the contractor.

Now it happens that the items of city work, except trenching, vary less in actual cost than almost any class of engineering work. This is due in large part to the fact that the cost of materials forms such a very large percentage of the total cost; and, obviously, the cost of materials is by no means so varying and uncertain an element as the cost of labor. For this reason there is a measure of justification for the practice of depending upon previous contract prices in estimating the cost of pavements, water mains, and much of the sewer work; and there is not an absolute necessity for the city engineer to know actual labor costs in order to make accurate forecasts.

On railway work, on the other hand, careful force accounts are usually kept by the engineering force; and, in consequence, an experienced railway engineer is usually a good judge of the probable actual cost of work of a given kind. His greatest errors are made in estimating the conditions to be met under the surface. He is proverbially inclined to accept a few outcrops of rock as being a sufficient guide in estimating the probable "classification." Test pits and soundings are apt to be few in number and shallow in depth. He blunders frequently in estimating the cost of bridge foundations, because of the lack of training in the necessity of "underground surveys" where underground work is to be done. He often finds that a shale cut which had been estimated on a ¼ to 1 slope has to be reduced to a 1 to 1 slope. He encounters clay slips wholly unexpected, because not systematically looked for before the work was begun. A long shallow rock cut, or even a deep one, develops where only earth was supposed to exist. Such, in a word, are some of the errors in cost estimating most common among railroad engineers.

Coming now to public works of magnitude, we find that their history has for the most part been such as to lessen public respect for the accuracy of "engineers' figures." Great canals, great dams, reservoirs, aqueducts, and the like, have so often exceeded many times the original estimates of cost as to bring engineers' estimates into public disrepute.

In our issue of Aug. 11, Mr. Samuel Whinery presented an able paper with which we are in accord, for the most part. We think, however, that he has laid undue stress upon the errors that arise from attempts on the part of engineers to "discount the future." A somewhat careful study of the history of the largest public works that have far exceeded engineers' estimates of cost, convinces us that rises in prices of materials and rates of wages are by no means the greatest factors in causing underestimates. It is, indeed, an exceptional occurrence, for rises in rates of labor or in prices of materials to have increased the estimated cost by 25%, whereas it is not exceptional to find an increase of 100% over the estimated cost of the work.

Any engineer engaged in estimating the probable increase in cost from changes in prices of labor and materials, should plot the curves of prices back for a generation or more, and with a full knowledge of the local conditions he should be able to say with considerable certainty that prices are not likely to rise above a certain definite limit during the progress of the work.

Possible rises in rates of wages, too, can be forecasted with considerable accuracy, for government bulletins show not only average wages but the highest averages in each occupation in the large cities and elsewhere in this country, for many years back. There is always the possibility of a strike for higher wages in any given occupation, but there is very little probability that the general average of wages paid on large public works will go above the best average paid in the largest cities for the same classes of workmen. With wage curves for the different classes of workmen in different cities and in the country, an engineer who has made a thorough study of the matter should be able to predict with considerable accuracy the maximum of the average rates of wages that may be paid on any given kind of public work.

We agree with Mr. Whinery that the engineer should base his estimates on existing conditions, but we do not agree with him in thinking that the engineer is not better qualified than others to "discount the future" in the matter of wages and prices. We insist, on the other hand, that these are factors which the engineer should make it his business to know better than any one else whose opinion is likely to be asked.

There are certain other elements that enter into the majority of efforts at "discounting the future," which should not form any part of an estimate made by public works engineers. It is customary to say that unforeseen contingencies will always arise on public works for which a percentage must be added, say, 25%, to cover possible modifications of plans, etc. Right here it is that the worst errors are made in estimating costs. Experienced engineers seldom fail to estimate, within a reasonable limit, the cost per cubic yard of earth excavation, of rock excavation, of masonry and the like. Where their estimates most often "break down" is in the quantity sheet. The amount of retaining wall masonry, or of piling, or of hard pan, or of rock, or of quicksand, or of development expense—these are a few of the items commonly *underestimated as to quantity*. It may be that the quantity of an expensive item is increased because too little time was spent in studying local conditions, or because the best methods were not used in making the study upon which the plans were based. The long list of underestimates credited to Erie Canal work is due almost entirely to lack of proper subsurface surveys, and proper study of conditions before making the preliminary estimates. In view of the fact that a great deal of time was apparently well spent in subsurface work and in studying conditions before making the estimate of cost of the proposed Barge Canal, we risk making the prediction that it will be the first great work of its kind done by the State of New York, which will not overrun the estimated cost. Be that as it may, the facts are incontrovertible that it has not been an increase in the unit prices for Erie Canal work over the engineers' estimates, but an increase in quantities arising either from a change of plans or from the discovery of unexpected materials that has made actual costs so far exceed estimated costs. In either case the increase in cost has been due to imperfect study of local conditions. It is true that there have probably been some fraudulent changes made in plans and in prices that have added to costs, but these do not account for the majority of underestimates.

By calling into consultation a number of well-known contracting firms, whose advice as to fair unit prices under given specifications may be relied upon, an engineer can hardly make an underestimate of the unit cost. The danger, then is that he may considerably overestimate the cost, but in any case, if the work is such that conditions can be sufficiently well described by word of mouth and by showing specimens of materials, an engineer should consult his friends among the contractors before coming to final conclusions as to fair unit prices. This does not mean that he should make no attempt to make an itemized estimate based upon his own knowledge, indeed no engineer is fit to estimate the cost of large public works who is not capable of making a fairly close estimate of every item of actual cost without outside assistance. By actual cost we mean the actual cost to the contractor. We agree with Mr. Whinery that the engineer should estimate excavation, for example, in detail, giving due weight to development work, loosening and loading, hauling, plant shifting, trimming up, bailing and draining, etc. It is not necessary, and oftentimes it is positively not desirable to make public such an itemized estimate. The engineer is a buyer and the contractor is a seller of a given kind and quantity of work and, as such, it is usually well that each shall make his own estimate without disclosing every item used in arriving at the unit price.

While the greatest errors in estimates of cost are not due to errors in estimating fair unit prices, there are, nevertheless, a number of good examples of work that has exceeded the engineer's estimate because the estimate on each item was too low. There are usually a few contractors who bid upon public works, basing their bids upon the engineer's estimate of cost, trusting that the engineer has made no mistakes. Certain sections of Erie Canal work have shown every evidence of having been awarded to contractors who erred in this manner by following engineers' estimates of unit cost that were themselves in error. The subsequent losses of such contractors are usually exaggerated, and the result is much higher bidding prices on similar work let at a later date.

The pendulum of prices swings to the other end of its arc, and the public foots the bill. The engineer, therefore, should exercise the greatest care in giving due weight to every cost item involved in arriving at a fair unit price; for intentionally or unintentionally to deceive contractors by estimates that are too low, in the end makes public work more expensive.

These are some of the many causes that have led to underestimates of cost, and after a knowledge of the causes of error it should be an easy matter to avoid such errors in the future if—if each new generation of engineers were only acquainted with the experiences of past generations. Errors continue to duplicate errors largely because students of engineering are graduated with little or no knowledge of the importance of accurate cost estimating and of how to make accurate cost estimates. They follow the line of least resistance as set forth in the opening sentence of this article, and instead of making accurate estimates of actual cost, they put their trust in previous bidding prices. On small works their errors are often of little or no importance, which simply serves to strengthen a bad habit, and they often go through life almost as ignorant of the itemized cost of each bidding unit, as the day they graduated. There are exceptions to this statement without number but the history of public works proves all too clearly that engineers who have had the making of estimates of the cost of great public works have not been masters of the art of cost estimating. Often through election, or through political appointment, undeserved by past record of achievement, engineers lacking in the proper training, having woefully underestimated the cost of public works. With few exceptions th se same engineers would not have made the blunders that have brought all engineers' estimates into such general disrepute, had they been trained at college in the methods of correct cost estimating. Even one lecture might have saved some of them from falling into the bad habit of basing estimates on previous contract prices. Another lecture on the history of public works contracts that are notorious examples of improper methods of studying conditions and improper methods of estimating, might have saved many an engineer from the disgrace of seeing his work finished at double his original estimate of cost. One or two lectures, however, should not be relied upon to furnish a sufficient knowledge of the proper methods of cost estimating. Every engineering problem in design should be made also a problem in economy, and it should be made apparent that the greatest economy can be effected only by the engineer who is the most thoroughly grounded in the art of cost estimating.

LETTERS TO THE EDITOR.

Superelevation in Deck Bridges on Curves.

Sir: The inquiry in Engineering News of July 21, under the caption "Superelevation in Deck Bridges on Curves," calls to mind some recent work on the C. B. & Q. Ry. on its Nebraska lines.

At the west end of Plattsmouth bridge across the Missouri the 125-ft. approach to the west main pier is on a sharp curve. Two 48-ft. girder spans separated by a 30-ft. tower span make up the approach. All of these girders are set normal to the track, which is superelevated 4 ins. for curvature. The end castings are of varying heights to provide for this, and the tops of tower posts are of different heights. This locates the feet of tower posts unsymmetrically with respect to center line of track. The run-off of this curve is on the 401-ft. 6-in. span and is made by putting a beveled oak block under each tie under the outside rail. These blocks are bolted to the ties.

At Thompson, Neb., a girder bridge on a 2° curve has girders set normal to the track. The pedestal castings are standard and the superelevation is obtained by making the tops of the concrete piers parallel with top of tie, which is neither notched or blocked.

At one bridge on double track near Plattsmouth, on a 6° curve, the two seats are on a slope, but with a step between, and the concrete is built for greater superelevation than the track now has. The rail seat carrying the bearing plates of the I-beams is blocked up at one end and surrounded by concrete.

On a C. & N. W. bridge at South Omaha, Neb., there are oak blocks on top of the ties to which the rails are spiked.

These are but a few of the methods employed which come to mind now. Yours truly,

F. T. Darrow,
Division Engineer, C. B. & Q. Ry.

Lincoln, Neb., Aug. 17, 1904.

Cost of Extra Fine Grinding of Cement.

Sir: On pages 112-113 of the Aug. 4 issue of Engineering News I note a discussion of the increased cost due to grinding cement so that 75% instead of 70% will pass a 200-mesh sieve. The editorial is of interest to me inasmuch as I had objected to the fineness requirement of the specifications in question when first prepared, not, however, because of the increased cost of such grinding, but because I thought the fineness required was unnecessary.

The above statement will explain that I am not biased in favor of the specifications in question. The present letter is merely a protest against an error that seems to be implicitly accepted in your editorial, viz.: That because the product of a given mill is reduced 25% to 30% by increasing fineness from 70% to 75% through a 200-mesh sieve, the cost of the cement will be increased in like ratio. This would be true if every mill on the clinker side of the plant were being run to its full capacity in grinding 70% cement, and if no new mills could be set to work. If, however, the mills on the clinker side were not running to their full capacity, or if one or two tube mills were added to do the extra fine grinding, the increase in cost would probably amount to much less than the 3 cts. per barrel which you state was the estimate of the "author of the specifications."

Letter No. 7, quoted by you, gives distinct utterance to the error in the following words: "Summing up, we have that an increase of fineness of 8% on 200-mesh represents an increase of horse-power as well as of cost of 37%." On looking over the details given in this letter we find that the increased fineness was gained not by decreasing the output of the plant, but by adding "one small tube mill" which required 32 HP. Now it is evident that the only increase in cost chargeable to the extra fine grinding is due to (a) interest on cost of tube mill, (b) coal burned in running tube mill, (c) extra labor in attending tube mill and (d) repairs and supplies. These four items could not, under the highest possible estimates, amount to over $9 per day. As the mill in question appears to be about a 600-barrel (in 24 hours) plant, the increased cost of fine grinding would therefore amount to not over 1½ cts. per barrel. Very respectfully,

Edwin C. Eckel.

U. S. Geological Survey, Washington, D. C.,
Aug. 5, 1904.

The Security Submitted with Bids.

Sir: Your editorial remarks in Engineering News of Aug. 18 on the subject of "Security Submitted with Bids" are timely and appropriate. The legitimate purposes of such security are:

(1) To reimburse the party inviting bids for the cost of readvertising and reawarding the contract, in case the contractor to whom an award may be made shall fail or refuse to enter into contract.

(2) To compensate the party receiving bids for losses and damages incident to the delay in the completion of the work, caused by the failure of the bidder to enter into contract.

Regarding the first, the sum is readily ascertainable, and is usually independent of the magnitude of the contract.

Regarding the second, it will usually vary with the urgency for the completion of the work, and the nature and magnitude of the losses and damages that will be entailed by delay. Obviously it may be different with each individual contract, and must be determined from the conditions of each; and, as between the several bidders at any one letting, will be independent of the amounts of the bids.

It would seem, therefore, that the amount of the security should be a fixed sum and not a percentage of amount bid. Also, there are good reasons why the amount of the security, while ample, should not be larger than is dictated by the above considerations. It is not always convenient or easy for even the larger contractors to provide the excessive sums that are sometimes required on large contracts, and desirable contractors of the less wealthy class may sometimes be thus discouraged from competing.

Furthermore, it may be doubtful whether the receiver of bids could maintain in the courts against a defaulting bidder a claim for a larger sum than will cover the actual loss and damage sustained, since the courts would be likely to apply in such cases the distinction between liquidated damages and penalties.

In view of the frequent cases where security submitted with bids is retained for an unexpected and unreasonably long time it would be fair and just to stipulate that if held beyond a stated period legal interest will be allowed. An example of the injustice that may otherwise result occurred in the case of a number of the contracts under the ill-fated Nine Million Dollar Canal Improvement enterprise in the state of New York. In the specifications it was stipulated that the sums submitted with the bids of contractors to whom awards were made would be held until the completion of the work. But the state ran out of money, the contracts were suspended and finally abrogated, and settlement with the contractors was delayed for years. In the meantime, the state retained the money submitted by these contractors with their bids, amounting in some cases to very large sums, and refused to allow more than 2% interest upon the money thus held, although the contractors were in no way to blame for the default of the state. S. Whinery.

New York, Aug. 19, 1904.

[Fortunately for contractors generally, the practice of holding certified checks until the completion of the work is by no means common. A few of the larger firms favor this practice because it limits competition to those who can command more capital than their smaller competitors to whom they can sublet at a profit after securing the work.—Ed.]

The Percentage of Cement in Mortar, Concrete and Masonry.

Sir: In the article headed "Rubble Concrete Dam for the Atlanta Water and Electric Power Co." in your issue of July 7 a great saving in cement is claimed for rubble concrete over rubble masonry, and the following illustration is given: "A short calculation will show the relative cost as compared with rubble masonry, viz.: Cyclopean work laid with 40% large stone and 60% concrete (1:2½:5) requires 7% of the volume to be cement. Rubble masonry laid with 65% large stone and 35% mortar (1:2½) requires 10% of the volume to be cement."

I have been unable to check these results and would be pleased to have you explain them. As concrete in the proportions given contains 20% of cement, and as 60% of the entire mass is concrete, 12% of the mass must be cement, and not 7%, as stated. Also, a mortar of the proportions stated would contain 40% of cement, and as 35% of the mass is stated to be mortar, 14% would be cement, and not 10%, as stated.

The Cheesman dam is of rubble masonry with one ashlar face, and is said to contain 72% stone and 28% mortar in the proportion of 1:2½, and would, according to my estimate, contain 11.2% cement, as against 12%, which would be required for the rubble concrete construction noted above.

In the Crow Creek dam, just completed by the city of Cheyenne, Wyo., a straight mortar rubble is used in the proportion of 1:4 for 81% of the dam and 1:3 for 19%. The stone forms 65.25%, and the mortar 34.75% of the mass. The amount of masonry is 14,420 cu. yds., and the cement used was 8,84.. barrels, making 9.08% cement, counting a barrel as 4 cu. ft., which was the rate at which it was proportioned in mixing. This agrees reasonably well with the percentage of cement calculated by the method used above, which gives 9.23%, but does not correspond with 7.28%, which would be given by the method used in the article referred to.

Yours very truly, A. J. Wiley.

Boise, Idaho, July 18, 1904.

[A proof of Mr. Wiley's letter was submitted to Mr. Wm. H. Cushman, and we append his reply.—Ed.]

Sir: Replying to Mr. Wiley's letter I would say that I do not think that my figures have been given sufficient consideration. I arrived at the percentages of cement in the concrete and rubble structures as follows:

My assumption is that in 1:2½:5 concrete the cement fills the voids in the sand (with a surplus), and that the mortar fills the voids in the broken stone (with a surplus), thus forming a dense mass. This dense mass, regardless of its measured volume, must consist of cement in the percentage represented by the fraction 1 over 8½. In using 60% of this concrete with 40% of large stone I combine two dense masses (voids do not enter into it), therefore the calculation would be as follows:

1 plus 2½ plus 5 equals 8½ proportions; and 1 over 8½ would be the percentage of cement in the resulting "dense mass," or 0.11765, which, multiplied by 60%, gives 0.0705, which is equivalent to 7%.

The rubble masonry work I figure similarly; i. e., 1 over 3½ is 0.2857, which, multiplied by 35%, gives 0.100625, or practically 10%.

I believe that this is the only correct assumption, as Mr. Wiley's method would lead to inconsistencies. He states that "1:2½:5 concrete contains 20% cement;" if this were true there would be 2½ times as much sand, or 50%; and 5 times as much stone, or 100%; all of these added would give 170% of the resulting "dense mass."

I think my point of view is made perfectly clear if the cement, sand and crushed stone proportions are each reduced to dense bodies before measuring the concrete proportions. This must be done by getting the percentages of voids in each of the component parts and eliminating them; otherwise a true proportion cannot be gotten.

Again Mr. Wiley's method assumes that the mortar just fills the voids in the broken stone; this would lead to error, as there is a surplus of mortar in the mixture quoted. Respectfully submitted,

Wm. H. Cushman.

Fulton, N. Y., Aug. 9, 1904.

The Deportation of United States Engineers from Canada.

Sir: Your editorial of Aug. 4 regarding employment of alien engineers on the Grand Trunk Pacific was doubtless prompted by the best possible motives, and there are few reputable engineers who will disagree with the general ideas therein expressed, but your view of the matter was limited and the whole question was begged when you stated that "it seems exceedingly difficult to believe" that there has been discrimination. It will be no more than fair that you should obtain Judge Winchester's report as soon as it is available and write another editorial after your knowledge of this question becomes more exact. I will, therefore, only touch on it because I am confident that when you are fully informed you will admit that a great injustice has been perpetrated, one that we Canadians will not tamely submit to so long as British ideas of wrong and right prevail. Personally, I deprecate the application of the alien labor law as not being in keeping with the dignity of our profession, and welcome to our country foreign engineers whose special knowledge may be of service to private corporations expending private funds, but the Grand Trunk Pacific Ry. will be practically a government road, as it is to be heavily subsidized in the West and built entirely out of public funds in the East, which places it on a par with your national and state works, for the service of which, as you are well aware, only United States citizens are eligible.

In Canada it is therefore felt that men having the interests of our country at heart should have direction of this great national enterprise in their hands, and that the public funds should be kept at home and not paid out to foreigners, who are usually only birds of passage.

As to discrimination, it is too well known now to admit of discussion. Although he has lived many years in this country, Mr. Hays did not make any serious effort to obtain a Canadian as Chief Engineer, and not knowing himself any one suitable in the United States he obtained through the Sante Fe road an engineer whom he had not previously known. This engineer in turn, having no following of his own, wrote letters to various parts of the United States and asked various parties to give him the names of railway engineers. These engineers, as soon as known, were offered much larger salaries than they were at that time receiving, and were brought into Canada perfect strangers, both to Mr. Hay and Chief Engineer Stephens; and at the same time hundreds of competent Canadian engineers had applied or had been mentioned by friends, but were systematically turned down, or offered low salaries, or put off from time to time with half promises, and when a few Canadians were employed they were paid less money than strangers for the same service.

Doubtless some worthless Canadians foisted themselves on the company and filled some of the minor positions with little credit either to themselves or their country. This will happen in any great enterprise, and most particularly when those at the head of it are all strangers.

Had a genuine effort been made to obtain "natives" of a good standing in the profession, all the positions on the road could have been filled with able, experienced men at moderate salaries, but still larger than they were and are still receiving.

Too much credence should not be placed on the rumors persistently heard regarding the personal and professional character of these alien engineers, of their futile wanderings through a wilderness with which their previous training did not fit them to cope. It is to be hoped for the honor of the profession that events will prove that whatever blunder has been perpetrated by the management of the company, all engineering so far done has been performed by honorable, competent engineers who have had sufficient experience to enable them to obtain as favorable a location for this great trunk line as could have been obtained by Canadian engineers experienced in this class of work in the same or similar regions.

Subscriber.

Niagara Falls, Ont., Aug. 15, 1904.

Sir: With reference to your editorial on the employment of engineers from the United States on the surveys for the Grand Trunk Pacific Ry., in your issue of Aug. 4, I would draw your attention to one or two points.

First, the Grand Trunk Pacific is considered to be a government work, and, as far as the writer knows, no government work in the United States is open to engineers who are not citizens of the United States.

Second, the whole trouble was brought on by the American engineers in charge of the surveys and other high officials of the Grand Trunk Pacific in what seems to have been a deliberate intention to employ Americans to the exclusion of Canadians equally well or better qualified. This point would undoubtedly have been overlooked if it had only extended to the employment of professional acquaintances, but, when Canadian engineers were told that "no Canadians were wanted" it was time to take some stand in the matter. The Canadian Pacific Ry. was a government-assisted work; its higher officials are chiefly of United States birth, and it has employed many engineers from the United States; but this raised no protest for the reason that Canadian engineers have always felt that there was no discrimination against them. To get a fair idea of the whole matter, imagine the outcry there would be among United States engineers if the Chief Engineer of the Erie Canal happened to be a Canadian and proceeded to bring nearly all his assistants from Canada. This supposition could not occur, however, as your laws are already framed to prevent it, and, as a matter of fact, the Canadian alien labor law is copied from the United States and would not be in existence today if the United States had not had one years before it was thought of in Canada. If the writer's recollection is correct, any United States corporation bringing in an engineer under contract from a foreign country is liable to a fine of $1,000 for each offense.

The writer has many friends among American engineers and if he felt that there was no unjust discrimination against Canadians he would, in this case, be entirely opposed to any enforcement of obnoxious laws; and for the ease of our American engineers' minds he would state that the protest would probably have been quite as great if the Grand Trunk Pacific had engaged all their engineers in England or any other country. I think also I am right in saying that the protest was not made by the Canadian Society of Civil Engineers, which contains a large majority of all civil engineers in Canada.

I quite agree with the editor of Engineering News that it is a mistake to draw national lines in civil engineering, but claim that in this matter Canadians are not doing it to any greater extent than it has been done in the United States for years.

Yours very truly,

M. Can. Soc. C. E.

Vancouver, B. C., Aug. 9, 1904.

Sir: Your editorial of Aug. 4, relating to alien labor laws in Canada, contains much that every right-thinking engineer will agree to. However, "Those in glass houses shouldn't throw stones." If Canada has an alien labor law, the text of it was secured from the United States, and it was only after years of exasperation that such a law could be passed in the House of Commons. The Grand Trunk Pacific project is a work of public importance; the money for its construction is being either wholly provided by the Government of Canada, or its guarantee is had in bonds to be issued by the Grand Trunk Pacific Co., hence it brings this work peculiarly within the scope and jurisdiction of the Parliament of Canada.

In the United States, and in most of, if not all of, the several states, there are statutes which declare that no alien can be employed upon works paid out of funds derived from taxation, in other words, the employee must be a citizen of the United States or else have declared his intention to become such. There can be no question that in the United States and each of the several states under such laws no foreign engineer can be employed on any public work.

Sir William Van Horne, Sir Thomas Shaughnessy, and other able Americans by birth came to Canada, doing grand work for the development of the country, and became citizens of the country.

The Grand Trunk Pacific staff are aliens pure and simple, and unfortunately conducted themselves in an offensive manner. Mr. Hays stated to the Premier, Sir Wilfrid Laurier, that 95% of the employees were Canadians. His subordinates misrepresented the state of facts to him, for no one believes Mr. Hays would state what he did not believe to be true.

The use of such phrases as "having to use the natives in the minor positions," and that more "American brains" would be required; the dismissal of capable Canadians to make room for imported men without standing in the profession, and such like conduct; the fact that no Canadian was asked to take an important position; that over 100 applications were not even acknowledged or replied to; all led to the feeling which you deplore.

If the Chief Engineer selected by Mr. Hays had been a man of standing in the profession, generally recognized as such, no such feeling would have resulted; he is not a member of the American Society of Civil Engineers, nor of any other recognized engineering society.

The agitation was begun by certain gentlemen in the Far West, who felt the injustice under which Canadians were suffering. The Canadian Society of Civil Engineers had nothing whatever to do with the investigation, and Canadian engineers are not in any sense responsible for the results.

It is upon the Government of Canada that the responsibility lies, and upon their action in the premise, now that the facts are all before them, will the people of Canada judge them.

We in Canada welcome able men of every country, and in private enterprises are using them; but in public works, having the bad example of the United States before us, are likely to limit the staff to citizens of the country.

Yours truly, M. Can. Soc. C. E.

Montreal, Canada, Aug. 6, 1904.

A TORNADO DID GREAT DAMAGE in St. Paul, Minn., on Saturday, Aug. 20. Many buildings were wholly or partially wrecked in the city and the surroundings, and a steel bridge over the Mississippi River was almost totally destroyed, it is stated. Several persons, possibly half a dozen or more, were killed in St. Paul, Minneapolis and surroundings by the storm.

THE WORLD'S FAIR ATTENDANCE at the St. Louis Exhibition has now passed the 7,000,000 mark, and the figures up to the end of July are as follows:

April (1 day)	187,793
May (25 days)	1,091,391
June (26 days)	1,124,833
July (27 days)	2,343,557
Total	4,657,577

ELECTRIC TROLLEY LINES WITHOUT RAILS have been tried in France and Germany, but according to a report from the U. S. Consul at Dresden, Mr. C. L. Cole, they are very expensive in operation. There are several lines of this sort in Westphalia and two others in the vicinity of Dresden, these latter being two and three miles long. Another line is being built in Prussia, between Mannheim and Langenfeld, 2½ miles, with two freight branches. Two trolley wires and poles are used for the main and return current. The motor cars will have two motors of 25 to 40 HP., and will haul two or three freight cars of five tons capacity. Passengers are to be carried in motor omnibuses with accommodation for 16 passengers. The speed will be 8 to 10 miles an hour and the fare 6 cts. for the entire trip. The road is 23 ft. wide, macadamized for a width of 15 ft., and has very few curves.

ITALIAN RAILWAYS are divided into two main systems: the Adriatic (or Southern), 3,600 miles, and the Mediterranean, 3,616 miles; secondary steam and electric railways aggregate 1,944 miles, and the Sicilian railways have 681 miles, making a total of 9,841 miles. Up to 1865, some railways were built by the government, and others under concessions, but all were operated by the government, which paid the construction companies 50% of the gross earnings. In 1865 the government railways were sold and concessions for both construction and operation were granted. In 1868, however, the government commenced to purchase the railways, but left their operation to the companies until 1878, when it took over the operation. In 1885 the government abandoned the purchase of the Adriatic Ry. and granted concessions for the operation of the railway system to three companies: the Mediterranean, the Adriatic and the Sicilian. These concessions will expire in 1905, and consequently there is a very active discussion as to whether they should be renewed (on the same or better terms), or whether the government should again undertake the operation. It is generally admitted, however, that the service must be improved and the railway system enlarged.

THE ENGINEERING HEADQUARTERS at the St. Louis Exhibition were not noted in the article on the engineering exhibits in our issue of Aug. 11, but it is of interest to note that several engineering societies are represented. The American Society of Civil Engineers has an office and reception room in the Liberal Arts Building, in charge of Mr. O. E. Mogensen, M. Am. Soc. C. E. Here also is an interesting collective exhibit of drawings and photographs furnished by some 30 members of the society, and files of the leading and foreign technical papers are kept for the benefit of visitors. The American Institute of Mining Engineers has a room or headquarters in the Mining Building, where also there are files of technical papers. The American Institute of Electrical Engineers has a booth in the Electricity Building. For railway men, engineers and others a large and comfortably equipped reading and reception room is open in the Transportation Building. In connection with this is the office of the St. Louis Railway Club. The French Society of Civil Engineers also has an office in the French section of the Liberal Arts Building. The various facilities and conveniences are at the disposal of visiting engineers at the exhibition, while the Engineers' Club of St. Louis also offers the use of its headquarters at 711 Pine St., St. Louis.

A BOND ISSUE OF $4,000,000 for improvements to the water supply of Manila, P. I., and for a sewerage system, was recently authorized by the Congress of the United States. An outline description of the proposed water-works improvements, written by Mr. J. F. Case, City Engineer of Manila, appeared in the "Far Eastern Review" (of Manila) for June, 1901, and from it the following statements have been extracted: It is proposed to develop an additional supply of water by building a dam on the Maraquina River, above centers of population and at a sufficient height to give a gravity flow. A masonry dam, 60 ft. high and 300 ft. long, on the crest, would afford a storage of some 2,500,000,000 gallons. The supply conduit would include a section of 42-in. steel pipe and other sections of masonry, partly in tunnel and partly in open cut. The minimum daily capacity of the conduit is estimated at 20,500,000 gallons per day, or nearly three times the present supply. Within the city the present distributing reservoirs would have their water level raised 25 ft., and the pipe system would be supplemented as required. The plans, Mr. Case says, have been approved, after a personal investigation on the spot, by Mr. Desmond FitzGerald, M. Am. Soc. C. E., of Brookline, Mass. The total estimated cost of the work is $1,800,000. It is hoped that bids can be invited by the close of the present year.